PB-228 806

WATER RESOURCES STUDY LAKE ERIE-OHIO RIVER CANAL BEAVER-MAHONING AND GRAND RIVER BASINS OHIO AND PENNSYLVANIA. A STUDY OF THE EFFECTS OF PROPOSED CANALIZATION ON WATER SUPPLIES AND WATER QUALITY AND OF POTENTIAL NEEDS AND VALUE OF WATER FOR MUNICIPAL, INDUSTRIAL, AND QUALITY CONTROL PURPOSES

Robert A. Taft Sanitary Engineering Center
Cincinnati, Ohio

June 1964

DISTRIBUTED BY:

NTIS

National Technical Information Service
U. S. DEPARTMENT OF COMMERCE
5285 Port Royal Road, Springfield Va. 22151

PB 228 806

WATER RESOURCES STUDY
LAKE ERIE-OHIO RIVER CANAL
BEAVER-MAHONING AND GRAND RIVER BASINS
OHIO AND PENNSYLVANIA

A Study of the Effects of Proposed Canalization on Water Supplies and Water Quality and of Potential Needs and Value of Water for Municipal, Industrial, and Quality Control Purposes

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service, Region V
Chicago, Illinois

and

Robert A. Taft Sanitary Engineering Center
Cincinnati, Ohio

in cooperation with

DEPARTMENT OF THE ARMY
U. S. Army Engineer District, Pittsburgh, Pennsylvania

Reproduced by
NATIONAL TECHNICAL
INFORMATION SERVICE
U S Department of Commerce
Springfield VA 22151

June 1964

TABLE OF CONTENTS

Section No.		Page No.
I	INTRODUCTION.	1
	Authority.	1
	Purpose and Scope.	1
	Acknowledgments.	2
II	SUMMARY AND CONCLUSIONS	3
	Summary.	3
	Conclusions.	5
III	DESCRIPTION OF THE CANAL PROJECT.	13
IV	DESCRIPTION OF THE AREA	14
	Location	14
	Topography	15
	Climate.	15
	Streamflow	15
	Existing Reservoirs.	17
	Chemical Quality of Surface Water. . . .	17
	Temperature of Surface Water	17
V	THE ECONOMY	21
	Economic Study Area.	21
	Extractives Industries	22
	Manufacturing.	24

TABLE OF CONTENTS (Cont.)

Section No.		Page No.
	Population.	25
	Future Growth	25
	Population Projections.	30
VI	WATER SUPPLY REQUIREMENTS.	32
	Past and Present Water Uses	32
	Additional Water Supply Needs	39
VII	WATER QUALITY CONTROL.	44
	Sources of Pollution.	44
	Surface Water Quality	45
	Water Quality Objectives.	47
	Temperature	51
	Flow Regulation Needs	52
VIII	BENEFITS OF STORAGE.	59
	Water Supply.	59
	Water Quality Control	61
IX	BIBLIOGRAPHY	70
	Appendix A	72
	Appendix B	76

LIST OF TABLES

Table No.		Page No.
1	Stream Discharge Data.	16
2	Major Storage Reservoirs	18
3	Surface Water Quality.	19
4	Agricultural Trends, 1939-1959	22
5	Employment and Location Quotient, 1950 and 1960. .	23
6	Population Trends, 1910-1960	26
7	Percent Employment in Selected Industrial Sectors, Ohio River Counties and the United States, 1960. .	28
8	Population and Employment Growth, Ohio River and Canal Counties, 1950-1960.	29
9	Population Projects, 1980-2060	31
10	Principal Municipal Water Supplies	33
11	Industrial Water Use by Major Firms, 1959.	35
12	Cooling Water Use from Mahoning River, Major Industries in the Youngstown-Warren Area	36
13	Industrial Water Use in Ohio, 1959	37
14	Industrial Water Use, Mahoning River Basin, Ohio 1959	38
15	Projected Municipal and Industr l Water Use . . .	40
16	Surface Water Quality, Beaver-Mahoning and Shenango Rivers in Pennsylvania, September 1959-September 1961	46
17	Regulated Discharge, Mahoning River at Youngstown.	53
18	Streamflow Requirements for Quality Control, Mahoning River at Youngstown	55

LIST OF FIGURES

Figure No.		Following Page No.
I	Location Map.	80
II	Temperature and Streamflow Relations.	20
III	Population Trends and Projections	32
IV	Location of Stream Sampling Stations.	46
V	Mahoning River Average Discharge, Velocity Relationship.	52

I. INTRODUCTION

Authority

In a letter dated March 7, 1962, the District Engineer, U. S. Army Engineer District, Pittsburgh, Pennsylvania, indicated that a re-evaluation is being made of its findings relative to a proposed navigation project between Lake Erie and the Ohio River contained in an unpublished report dated August 12, 1947, which is a review of the part of House Document 178 of the 76th Congress, 1st Session, entitled "Lake Erie and Ohio River Canal, Pittsburgh-Ashtabula Route." As a result a request was made of the Public Health Service to investigate and report on probable effects of the proposed canal project on municipal and industrial water supply and water quality.

The study of municipal and industrial water supply needs is conducted in accordance with the Memorandum of Agreement, dated November 4, 1958, between the Department of the Army and the Department of Health, Education, and Welfare relative to the Water Supply Act (Title III of Public Law 85-500, as amended by P.L. 87-88). Determination of the need for streamflow regulation for quality control is carried out in accordance with provision of the Federal Water Pollution Control Act (Public Law 84-660, as amended by P.L. 87-88).

Purpose and Scope

The purpose of this study is to determine the effects of the proposed Lake Erie-Ohio River Canal project on municipal and industrial water supplies

and on surface water quality in the Beaver-Mahoning and Grand River system and to determine the need for and value of additional storage in the project for municipal and industrial water supply and water quality control. Available information on municipal and industrial water use and the effects of water use on quality has been used. While the conclusions reached are considered adequate for preliminary planning purposes, they should be reviewed and revised on the basis of more refined analysis of field data to be collected in connection with the Public Health Service's Ohio River Basin Project study.

The study area consists of the counties most closely approximating the drainage areas of the Beaver, Mahoning, and Grand Rivers, extending from Lake Erie to the Ohio River. A 100-year period of analysis has been used in this study.

Acknowledgments

The cooperation and assistance of several agencies is gratefully acknowledged. Special appreciation is expressed to the following:

Ohio State Department of Natural Resources

Pennsylvania State Department of Health, Division of Sanitary Engineering, Bureau of Environmental Health

Ashtabula County Planning Commission

Mahoning Valley Industrial Council

II. SUMMARY AND CONCLUSIONS

Summary

1. The Beaver-Mahoning River is a tributary of the Ohio River. The basin is located in northeastern Ohio and western Pennsylvania. The Grand River discharges to Lake Erie and the basin is located in northeastern Ohio.

2. The proposed Lake Erie-Ohio River Canal will follow the general route of the Beaver and Mahoning Rivers from the Ohio River to a point above Warren, Ohio. It will then cut across a divide separating the Ohio River and Lake Erie drainage basins and enter a large proposed impoundment called Summit Reservoir, which will be formed by a dam on the Grand River near Harpersfield, Ohio. From there the canal will follow the general route of the Grand River to terminate in Lake Erie at Painesville, Ohio.

3. The 1960 population in the Beaver-Mahoning and Grand River Basins was slightly in excess of one million. About 73 percent of the population is in cities and villages. The largest community is Youngstown, Ohio, which had a 1960 population of 166,631. The Youngstown-Niles-Warren area is the largest center of population in the study area and had a population of 418,330 in 1960. This is a steel-producing area, and about 48 percent of the labor force is employed in this industry.

4. Municipal water use in the area amounts to about 96 mgd of which 48.55 mgd is used in the Youngstown-Niles-Warren area. Information from the State of Ohio indicates that about 28.2 mgd of this use is for industrial purposes. Most of the communities obtain water supplies from surface sources.

5. Industrial water use in the study area in Ohio is reported to be 1,198.5 mgd. Data for industries in Pennsylvania are not available at this time, but available supplies are considered to be adequate to meet present needs along the Beaver River. Cooling water use in the Youngstown-Niles-Warren area amounts to about 1,036 mgd, but this involves extensive reuse and does not require drinking or process water quality. Storage in Berlin, Mosquito Creek, and West Branch (under construction) Reservoirs totaling 181,000 acre-feet has been provided to regulate streamflows for control of temperature for industrial water supply use. Purchases from municipal systems and from a private water company and pumpage from wells amount to 43.4 mgd and constitute the major portion of industrial sanitary and process water use in the Youngstown area.

6. Present surface water supply sources in the Youngstown-Niles-Warren area provide 93,200 acre-feet of storage and ensure a supply of about 110 mgd. Water supply storage of 19,400 acre-feet in the Shenango River ensures supplies at Sharon and New Castle in Pennsylvania.

7. Serious dissolved oxygen and temperature problems exist in the Mahoning River in the reach between Warren and Lowellville, Ohio, and dissolved oxygen levels below 4 mg/l have been noted as far downstream as Ellwood City in Pennsylvania. Stream temperatures in excess of 100°F are not uncommon in the Mahoning River in the Youngstown area. With present heavy loads stream temperatures average approximately 37°F above normal. Many kinds of wastes reach the stream from various sources resulting in a grossly polluted river. Phenols as high as 0.10 mg/l were noted in a recent study by Pennsylvania at a station on the Mahoning River just above the confluence of the Shenango River.

8. Presently available flow regulation facilities are operated to minimize temperatures at industries in the Youngstown-Warren area. Minimum flows ranging from 185 cfs in winter to 470 cfs in summer and averaging 275 cfs can be maintained. With completion of West Branch Reservoir, currently under construction by the Corps of Engineers, minimum flows ranging from 220 cfs in winter to 520 cfs in summer and averaging 365 cfs will be maintained resulting in some improvement in water quality. Quality control needs and benefits are based on flows available after completion of West Branch Reservoir.

Conclusions

1. The economic base study for the basins indicates that substantial increases in population may be expected even though prospects are that the rate will be less than the national average. The population of the study area is expected to increase from 1,066,000 in 1960 to 1,464,000 by 1980; 2,000,000 by 2010; and 3,300,000 by 2060. The greatest concentration of population is expected to continue to be located in the Youngstown-Niles-Warren industrial complex along the Mahoning River. The population of this highly industrial area is expected to increase from 418,330 in 1960 to 578,000 by 1980; 800,000 by 2010; and 1,320,000 by 2060.

2. Considering the increases in population forecast for the study area and the considerable water use from municipal sources by industries, it is expected that municipal water use will increase from the present 111 mgd to 176 mgd by 1980; to 283 mgd by 2010; and to 520 mgd by 2060. In the

critical Youngstown-Niles-Warren area water use is expected to increase from the present 63.7 mgd to 101 mgd by 1980; to 160 mgd by 2010; and to 264 mgd by 2060. These figures are considered to include a reasonable allowance for future industrial water use other than for cooling purposes.

3. Considering the limited amount of water available for development, it is expected that further expansion of water use by heavy water-using industry will be limited. With the trend toward use of less water per unit of production in the primary metals industry, no substantial increase in industrial water use by this industry in the Youngstown-Warren area is expected. Possible development of heavy water-using industry at Painesville is expected to make use of Lake Erie as a source of supply while water use in the Beaver Falls-New Brighton area in excess of available flows could be supplied from the Ohio River. It is not expected that water supply needs of other areas would be secured from the reaches of the Beaver-Mahoning or Grand Rivers under study.

4. Additional municipal water supply will be needed in the Youngstown-Warren area by about 1980. By 2010 an additional 50 mgd will be required to meet expected needs. By 2060 the required increase will be 154 mgd. Provision for these increased needs by allocation of storage in Summit Reservoir would have an average value over the life of the project of $357,000 per year if 2010 needs are met and $757,000 per year if 2060 needs are met. Provision for water supply storage in a single-purpose reservoir is considered the most economical alternative to Summit Reservoir. The value of storage is based on generalized data on the cost of reservoirs in the general vicinity. Since municipal water supplies are secured from off-stream sources, it is not anticipated that construction of the proposed canal will affect water supplies.

5. Industrial water use for sanitary and process purposes is included with the municipal water needs. It is anticipated that cooling water needs can be met by a combination of available regulated flows and additional off-stream cooling. While the higher pool levels should reduce pumping costs, the savings will depend on the location of the major industrial withdrawals and have not been estimated.

6. Evaluation of water quality control needs in such a highly industrialized area and with such a radical change in the hydraulic regimen, as will result from canalization, is extremely complex. Consideration of the combined effects of organic and thermal wastes on dissolved oxygen concentrations and on temperature in the Mahoning River in and below the Youngstown-Niles-Warren area has been the basis for the need for storage for water quality control.

7. Allocation of storage in Summit Reservoir to water quality control will result in improvement in water quality for instream and withdrawal uses in and below the Youngstown-Niles-Warren area throughout the length of the Beaver-Mahoning River and in the Ohio River. Based on the current trend to greater water-oriented recreational activities, a Lake Erie-Ohio River Canal will be extensively used for pleasure boating. Maintaining clean waters along this waterway will enhance its recreational use, provide a desirable access to Summit Lake's vast recreational opportunities, and improve local water-oriented recreational use, including fishing, over its length. These benefits are considered widespread in nature.

8. Based on provision of adequate waste treatment (considered to be a minimum of 85 percent first-stage BOD removal and reduction of temperature to 93°F), as required under the Federal Water Pollution Control Act, it is estimated that the following flows and associated drafts on storage will be needed to maintain a minimum of 4 mg/l of dissolved oxygen in the Mahoning River under present (uncanalized) conditions:

Year	Required Flow, cfs			Draft on Storage
	winter	summer	mean	acre-ft/yr
1960	240	515	387	50,000
1980	290	710	480	107,000
2010	350	850	565	151,000
2060	500	1,030	723	253,000

9. Canalization of the Mahoning River will reduce the reaeration capacity of stream as a result of the increased depth and decreased velocity. It is estimated that the following flows and associated drafts on storage will be required to maintain acceptable dissolved oxygen concentrations under canalized conditions:

Year	Required Flow, cfs			Draft on Storage
	winter	summer	mean	acre-ft/yr
1960	320	930	584	169,000
1980	410	1,000	663	208,000
2010	500	1,100	756	276,000
2060	670	1,300	966	427,000

On an annual basis, quality control flow needs will be increased by an average of 206 cfs as a result of canalization.

10. The total value of benefits resulting from flow regulation to meet quality control needs, including the thermal benefits, has been evaluated in terms of the cost of the most economical alternative. In this study this is considered to be a single-purpose reservoir sufficient to meet quality control needs in the absence of canalization. The required drafts on storage under canalized conditions, the draft on storage in the absence of canalization upon which benefits are based, and the resulting benefits are listed below:

Year	Draft on Storage, acre-ft/yr		Average Annual Value of Benefits, dollars
	canalized	uncanalized	
1960	169,000	50,000	318,000
1980	208,000	107,000	1,020,000
2010	276,000	151,000	1,165,000
2060	427,000	253,000	1,405,000

The value of storage is based on generalized data on the cost of reservoirs in the general vicinity.

11. Elevated temperatures resulting from heated discharges reduce the value of water for further cooling, decrease the rate of stream reaeration by reducing the dissolved oxygen saturation level, increase the rate of biological decomposition of organic wastes, and when changes are rapid or extreme, restrict the development of fish and other aquatic life. It has been assumed that off-stream cooling will be provided to maintain stream temperatures at or below 93°F and that this constitutes adequate thermal waste treatment, as required under the Federal Water Pollution Control Act. Reduced stream temperatures resulting from streamflow regulation to control dissolved oxygen quality will benefit

industry by increasing plant cooling efficiencies with flow to be provided under canalized conditions to meet quality control requirements, stream temperatures will be reduced resulting in the benefits to industrial water users as follows:

Year	Temperature Reduction at Youngstown, °F	Average Annual Vales of Benefits, dollars
1960	6	342,000
1980	10	570,000
2010	14	800,000
2060	22	1,250,000

Reduction of the temperature of heated water discharges to ambient temperatures would reduce average annual flow requirements under canalized conditions by an estimated 193 cfs.

12. An average of 123,000 acre-feet additional draft on storage will be required as a result of canalization. Failure to provide for this draft on storage to offset decreased waste assimilation capacity in connection with the navigation project will result in a damage to water quality in the Beaver-Mahoning River. In terms of generalized costs of a single-purpose reservoir in the study area capable of providing the necessary draft on storage in 9 years out of 10, this damage is estimated to be $1,250,000 per year over the life of the project.

13. Since the average annual discharge of the Mahoning River at Youngstown of 854 cfs is only slightly higher than average water quality control flow needs of 723 cfs (for uncanalized conditions) anticipated in 2060 at the end of the study period, it can be seen that the water resources

development of the Mahoning River Basin is approaching the limit of present technology. In fact, with canalization, required flows of 966 cfs exceed average annual flows at Youngstown and water importation or utilization of technological developments not yet known will be necessary.

14. It is anticipated that most of the municipal and industrial wastes from the Painesville area will be discharged to Lake Erie rather than to the Grand River after adequate treatment but that a portion of the treated waste effluent and uncontrolled waste, such as surface runoff and storm water overflow from the Painesville area, will continue to reach the Grand River below the canal cutoff. By 1990 natural flows would be insufficient to assimilate anticipated waste loads and flow regulation would be needed. It is estimated that the following flows and associated drafts on storage will be needed to maintain the water quality objective of 4 mg/l of dissolved oxygen established for this reach of river:

Year	Required Flow, cfs			Draft on Storage acre-ft/yr	Average Annual Value of Benefits, dollars
	winter	summer	mean		
1960	10	20	15	none	none
1980	15	25	20	none	none
2010	25	55	40	7,500	34,500
2060	40	90	65	20,000	75,000

Provision of necessary control works or flow regulation to flush this reach of river and maintain acceptable water quality is estimated to provide benefits as shown above. Benefits have been evaluated in terms of the cost of the most economical alternative which is considered to be a single-purpose project capable of maintaining the required flow under uncanalized conditions.

15. The estimated water supply and quality control needs and the value of benefits reported herein are considered reasonable for project evaluation but should be considered tentative pending completion of comprehensive studies presently being conducted by the Public Health Service in the Great Lakes and Ohio River Basins.

III. DESCRIPTION OF THE CANAL PROJECT

The proposed Lake Erie-Ohio River Canal (see Figure I in back of report) will follow the general route of the Beaver and Mahoning Rivers from the Ohio River to a point above Warren, Ohio, where it will depart from existing stream channels and cut across a divide separating the Ohio River and Lake Erie drainage basins and then enter a large impoundment called Summit Reservoir, which will be provided as part of the project. This reservoir will be formed by a dam on the Grand River near Harpersfield, Ohio, and will be 115 feet high from the streambed to the spillway crest. The canal will connect the reservoir to Lake Erie by following the Grand River channel to the lake near Painesville, Ohio.

This proposed navigation waterway will be about 120 miles long and will be controlled by a system of 11 locks and dams. Eight locks and dams with a combined lift of 159 feet will be required in the Beaver-Mahoning River portion of the route and three locks and dams with a combined lift of 271 feet will be required in the Grand River portion between Summit Reservoir and Lake Erie. Summit Reservoir will provide the water needed to operate the canal system and, when full, will impound about 2,000,000 acre-feet of water and have a surface area of 110 square miles.

The total watershed controlled by Summit Reservoir will be 1,455 square miles; 899 square miles will lie in Mahoning River Basin, and 556 square miles in Grand River Basin. The proposed storage capacity would allow for nearly complete control of the runoff from the drainage areas contributing to the Summit Reservoir.

IV. DESCRIPTION OF THE AREA

Location

The combined Beaver-Mahoning-Grand River Basins are located in western Pennsylvania and northeastern Ohio and are bounded by Lake Erie to the north and the Ohio River to the south. These basins cover an area of 3,867 square miles.

The Beaver River begins at the confluence of the Mahoning and Shenango Rivers. The Shenango River drains an area of 1,070 square miles. The Beaver River flows in a southerly direction for about 21 miles to join the Ohio River at Rochester, Pennsylvania, which is 25 miles below Pittsburgh, Pennsylvania. The watershed directly tributary to the Beaver River covers 948 square miles.

The Mahoning River drains an area of 1,132 square miles. It flows northeast to Warren, Ohio, at which point it turns to the southeast and flows through Youngstown, Ohio, to join the Shenango River at New Castle, Pennsylvania. Its principal tributaries are West Branch, Eagle Creek, Meander Creek, and Mosquito Creek.

The Grand River drains an area of 717 square miles. It flows north to within a few miles of Lake Erie and then west to Painesville. It discharges to Lake Erie at Fairport Harbor, Ohio.

On the lower reaches of the canal in the Beaver River Basin there is an additional 2,251 square miles of tributary drainage area which is

partially controlled by Pymatuning Reservoir on the Shenango River. When Shenango River Reservoir (now under construction) is completed a minimum streamflow of 300 cfs will be assured during the summer months (April through October) in the Shenango River at New Castle, Pennsylvania.

Topography

The topography of the Grand and Mahoning River Basins is characterized by rolling hills and glacial plains as is generally characteristic of glaciated regions. The same is true of the upper part of the Beaver River Basin. The eastern and southern part of this basin could be classed as a dissected plateau.

Climate

The monthly average temperature is highest in July and lowest in February, ranging from 72 to 28°F. Precipitation varies from 33.5 inches at Youngstown to 38 inches along the Mahoning-Grand River divide, then decreases to 35 inches around the mouth of the Grand River. Monthly average precipitation is maximum in July at 3.7 inches and minimum in February at 2.2 inches. The annual average snowfall is about 50 inches.

Streamflow

Table 1 lists minimum and average discharge data for the principal stream measurement stations in the Beaver-Mahoning and Grand River Basins as reported in the USGS water supply papers for 1960.

Table 1

Stream Discharge Data
Beaver-Mahoning and Grand River Basins

River	Station	Drainage Area square miles	Length of Record years	Discharge, cfs	
				Average	Minimum of Record
Mahoning River	Leavittsburg, O.[a,d]	580	20	579	55
" "	Youngstown, O.[a,b,d,e]	899	39	854	28
" "	Lowellville, O.[a,b,d,e]	1,076	18	1,111	125
Shenango River	Sharpsville, Pa.[c]	588	22	748	38
Beaver River	Wampum, Pa.[a,b,c,d,e]	2,235	32	2,382	74
Grand River	Madison, O.	587	35	668	0.2

a/ Flows regulated by Milton Reservoir since 1916.
b/ Flows regulated by Meander Creek Reservoir since 1929.
c/ Flows regulated by Pymatuning Reservoir since 1933.
d/ Flows regulated by Berlin Reservoir since 1942.
e/ Flows regulated by Mosquito Creek Reservoir since 1943.

Existing Reservoirs

Table 2 lists the larger flow regulating reservoirs[1] in the study area presently in service or under construction. A number of smaller reservoirs used for municipal water supply and power generation are scattered throughout the Mahoning and Beaver River Basins. Low head dams along the Mahoning River from Warren to Lowellville are used by riparian industries as sources for cooling and process water.

There are small dams on the Grand River that are used for both municipal and industrial purposes although they provide no significant flow regulation for the basin.

Chemical Quality of Surface Water

Table 3 summarizes recent observations of the chemical quality of surface water in the study area obtained by the Water Pollution Control Unit of the Ohio Department of Health.[2] Maximum and minimum values are shown. Results for the lower Beaver River are based on an extensive 2-year sampling program by the Pennsylvania State Health Department.

Temperature of Surface Water

Before Berlin and Mosquito Creek Reservoirs were built, river temperature at Youngstown reached as high as 130°F when streamflows were less than 40 cfs. Flow regulation provided by these reservoirs has prevented such extremely high temperatures, although it is estimated that temperatures may

Table 2

Major Storage Reservoirs
Beaver-Mahoning and Grand River Basins

Reservoir	Date Completed year	Location of Dam	Drainage Area square miles	Storage Capacity, acre-feet			Safe Water Supply Yield mgd	Owner or Operator
				Water Supply	Flow Regulation	Total[a]		
Berlin	1943	Mahoning River 35 miles above Warren	(249)	19,400	58,800[b]	91,200	34	Corps of Engineers
Milton	1917	Mahoning River 5 miles above Newton Falls	276	-	-	29,700	-	City of Youngstown
West Branch	Under construction	West Branch 11 miles above mouth	81	-	52,900[c][d]	78,700	-	Corps of Engineers
Mosquito Creek	1944	Mosquito Creek 9 miles above mouth	97	11,000	69,400[b]	104,100	16	Corps of Engineers
Meander Creek	1930	Meander Creek 2 miles above mouth	85	30,800	-	35,370	30	Mahoning Valley Sanitary District
Eight projects	Between 1907 and 1949	Yellow Creek (4) Squaw Creek (3) Dry Run	50 (est.)	22,000	-	22,000	27	Ohio Water Service Company
Pymatuning	1934	Shenango River 1.6 miles above Jamestown	(158)	19,400	159,900	198,200	N.A.	Commonwealth of Pennsylvania
Shenango River	Under construction	Shenango River 2 miles above Sharpsville	589	-	30,000	192,400	-	Corps of Engineers
		Total	1,178	102,600	371,000	751,740	-	

[a] Includes storage for silt, flood control, and other purposes.

[b] Flow regulation storage provided by direct legislation to maintain flows for industrial cooling water use.

[c] In winter 11,200 acre-feet of storage capacity are transferred to flood control.

[d] Flow regulation storage provided with local cooperation for industrial cooling water use.

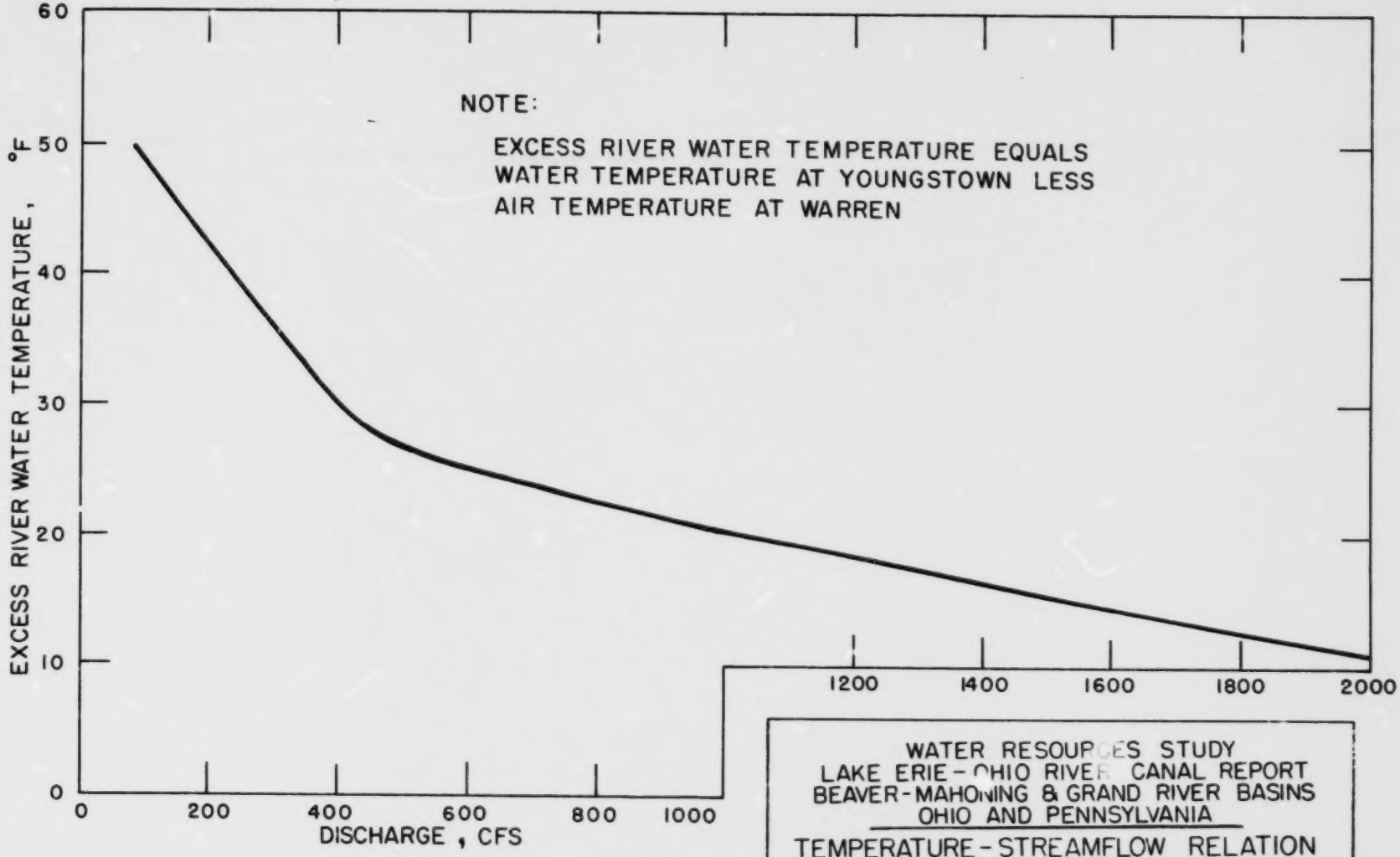
Table 3

Surface Water Quality[2/]
Beaver-Mahoning and Grand River Basins

Location	Maximum and Minimum Concentrations, mg/l				
	Cl	SO_4	Fe	Hardness as $CaCo_3$	Dissolved Solids
Grand River					
Near Ashtabula-Trumbull Co. Line, Ohio	10-12	54-55	0.44-0.69	150-184	178-245
Near Madison, Ohio	7-10	41-55	0.02-0.04	110-156	161-214
Near Painesville, Ohio	186-11,100	33-112	0.02-0.68	201-9280	430-18,900
Mahoning River					
Near Levittsburg, Ohio	6-25	56-122	0.01-0.14	91-195	142-296
Near Niles, Ohio	5-12	59-517	0.01-4.1	59-501	14-736
Near Youngstown, Ohio	8-47	68-264	-	113-288	170-518
Near Lowellville, Ohio	10-64	74-328	0.1-20.0	107-328	182-629
Beaver River					
Near New Brighton, Pa.	6-33	38-162	0.1-8.4	74-203	121-372

still rise to about 112°F for periods up to a week in duration in the summer season if steel mills are operating at about 85 percent of capacity.

Data on water temperatures in the Mahoning River in the Youngstown area collected by public and private organizations over many years have been made available by the State of Ohio. River temperatures are related to air temperature, streamflow, and the heat added through industrial cooling operations. The temperature-streamflow relationship shown graphically on Figure II was developed from data from these sources. Heat in cooling water discharged to the Mahoning River may be considered a pollutant since high raw water temperatures adversely affect the use of the water for further cooling, increase production costs, and affect the stream's ability to assimilate organic wastes by reducing the dissolved oxygen available at saturation and increasing the rate at which biochemical oxidation or organic wastes takes place. Aquatic life depending on dissolved oxygen has been almost entirely eliminated from the Mahoning River in the Youngstown area.



WATER RESOURCES STUDY
LAKE ERIE - OHIO RIVER CANAL REPORT
BEAVER-MAHONING & GRAND RIVER BASINS
OHIO AND PENNSYLVANIA

TEMPERATURE - STREAMFLOW RELATION
MAHONING RIVER AT YOUNGSTOWN

DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION V CHICAGO, ILL.

FIGURE II

V. THE ECONOMY

Economic Study Area

The area covered by the economic study in this report approximates the watershed boundary of the Beaver, Mahoning, and Grand Rivers. For purposes of population projections, it includes part or all of the following counties: Ashtabula, Lake, Mahoning, Trumbull, Geauga, Portage, Stark, Columbiana and Crawford in Ohio, and Lawrence, Mercer, Butler, and Beaver in Pennsylvania. It is estimated that about 90 percent of the population in this area actually resides within the watershed boundary.

It is recognized in the economic study that the area of economic influence extends beyond the watershed boundaries in many instances. For example, Beaver County is part of the Pittsburgh economic area while Lake and Geauga Counties fall within Cleveland's sphere of economic influence. Mahoning and Trumbull Counties constitute a separate iron- and steel-producing region. The other counties within the economic study area are interdependent but are also related to outside economic areas. Consequently, areas external to the river basins were also considered in analyzing past and present economic conditions and evaluating prospects of future economic growth. For employment and industrial classification, the counties of Mahoning and Trumbull in Ohio and of Beaver, Butler, Lawrence, and Mercer in Pennsylvania were considered to be sufficiently homogeneous to be studied as an economic unit.

Extractive Industries

In Table 4 recent trends in agriculture in the study area are compared with trends in the States of Ohio and Pennsylvania and the United States. For the years 1939 to 1959 the value of farm output in the study area increased only half as rapidly as in the United States. While the average value per farm in the study area increased, it increased only about one-third as much as the average for the United States. However, Table 5 indicates that agriculture is relatively less important in the study area than in the nation as a whole.

Table 4

Agricultural Trends[a/]
1939-1959

	Beaver-Mahoning-Grand River Basin	Ohio	Pennsylvania	United States
Number of Farms	-2.0	-2.0	-2.0	-2.0
Average Value per Farm[b/]	+5.4	+7.6	+5.0	+14.3
Acres Harvested	-0.9	0.0	-4.4	-0.2
Value of Output[b/]	+1.0	+2.0	+2.4	+2.0

[a/] Trends are expressed as average annual percentage changes from 1939 to 1959.

[b/] Expressed in terms of a constant 1959 dollar value.

Table 5

Employment and Location Quotient[a/]
Beaver-Mahoning and Grand River Basins
1950 and 1960

Employment Category	1950 Number	1950 Percent	1950 L.Q.	1960 Number	1960 Percent	1960 L.Q.
Agriculture	13,282	3.7	0.3	8,016	2.0	0.3
Mining	4,226	1.2	0.8	2,281	0.6	0.7
Manufacturing	162,056	45.6	1.9	167,986	42.6	1.7
Durable Goods	147,935	41.7	3.2	149,941	38.0	2.7
Furniture, Wood & Lumber Products	5,247	1.5	0.8	3,909	1.0	0.7
Primary Metals	89,895	25.3	13.3	88,306	22.4	12.4
Fabricated Metals[b/]	41,555	11.7	1.6	48,197	12.2	1.4
Other Durables	11,238	3.2	1.7	9,529	2.4	1.2
Nondurable Goods	14,121	4.0	0.3	18,045	4.6	0.4
Food & Kindred Products	3,571	1.0	0.4	5,271	1.3	0.5
Textile Mill Products	212	0.1	c/	476	0.1	c/
Apparel & Other Fabrics Textile Products	1,153	0.3	0.2	875	0.2	c/
Printing & Publishing	2,444	0.7	0.5	4,058	1.0	0.6
Chemical & Allied Products	1,864	0.5	0.5	2,616	0.7	0.6
Other Nondurables, NEC	4,877	1.4	0.5	4,749	1.2	0.5
Total Extractive & Manufacturing	179,564	50.6	1.3	178,283	45.2	1.4
Service	157,325	44.3	0.8	190,942	48.4	0.8
Educational	10,009	2.8	0.8	16,708	4.2	0.9
Public Administration	7,640	2.2	0.5	9,396	2.4	0.5
Military	220	0.1	c/	365	0.1	c/
Other	139,456	39.3	0.8	164,473	41.7	0.8
Unemployed	18,260	5.1	1.1	25,567	6.5	1.3
Labor Force	355,149			394,792		
Population	897,317			1,066,305		
Percent of Labor Force to Population		39.6			37.0	

[a/] The location quotient (L.Q.) is a measure of the relative importance of each industrial category to the economy of the study area. Thus, for a selected industrial category,

$$\text{location quotient} = \frac{\text{pct. of area labor force in category}}{\text{pct. of national labor force in category}}.$$

[b/] Includes machinery electrical equipment, and all transportation equipment.

[c/] No location quotient was computed for industries employing less than 1,000 workers. In each such case, however, the L.Q. was less than 0.1.

The mineral resources of the region are almost entirely limited to construction materials for local use. Minerals currently being extracted include clay, stone, gravel, limestone, peat, and bituminous coal (found in isolated seams). No other minerals are known in the area. Raw materials used for the manufacture of primary metals in the Youngstown-Warren area are imported from outside the basin.

Manufacturing

The economy of the region as revealed by employment statistics for 1950 and 1960 is heavily dependent on manufacturing. The region is well above the national average in percentage of total employment engaged in manufacturing, but in all other industries, it is substantially below the average for the United States. The greatest disparity is in the resource-oriented industries.

Table 5 shows a breakdown of employment for 1950 and 1960 by sub-industry category. The proportion employed in the manufacture of primary metals in the study area was over 12 times that in the United States in 1960. The region also had a greater proportion employed in the fabrication of metals than did the nation as a whole. In other manufacturing categories, the region had substantially lower representation than the United States. A comparison of employment in subindustrial categories indicates that the proportion has remained relatively unchanged between 1950 and 1960.

The high degree of specialized employment in the primary metals and metal-working industries has made the area highly dependent on the activities

of these industries. Over-dependence on the primary metals industry for economic growth and development has drawbacks because that industry is subject to substantial cyclical variations. Furthermore, increased automation and mechanization in production may be expected to reduce opportunities for employment in these industries. The iron and steel industry in the study area is also losing its relative portion of national markets, though new markets are being sought.

Population

Trends in population for the Beaver-Mahoning and Grand River Basins can be seen in Table 6. The population of urban and incorporated communities and towns contained 764,392 people, or 73 percent of the entire population in 1960. Principal industrial cities in the area located on the proposed waterway include Youngstown, Warren, Niles, New Castle, and Painesville. Other important industrial cities in the basin are Alliance and Sharon, Ohio, which are important steel-producing centers, but are not located on the waterway under study.

Future Growth

With no strong competitive advantage in the resource-based industries of agriculture and mining, future economic growth of the Beaver-Mahoning and Grand River Basins is likely to depend on these two economic premises: conserving the existing primary metals industry and stimulating the development of industry and employment in categories other than the primary metals industry.

Table 6

Population Trends
Beaver-Mahoning and Grand River Basins
1910-1960

Area [a]	1910	1920	1930	1940	1950	1960
Beaver Falls-New Brighton	48,159	53,937	68,910	69,408	78,638	94,485
Youngstown-Niles-Warren	129,783	228,829	305,633	314,202	345,819	418,330
Painesville	9,601	14,019	18,673	20,472	25,501	31,146
Alliance	15,083	21,603	23,047	22,405	26,161	28,362
Sharon	34,602	48,318	50,963	50,366	53,639	59,569
Ellwood City	3,902	8,958	13,332	13,296	14,067	13,871
New Castle	36,831	45,858	49,712	48,636	54,003	54,391
Butler	26,963	31,470	32,209	33,725	35,551	36,194
Cities, 2,500 to 10,000	16,840	22,608	27,638	27,313	38,786	43,088
Total Urban	321,764	475,600	590,117	599,823	672,165	779,436
Villages, 1,000 to 2,500	12,863	15,387	17,063	18,004	25,689	29,189
Villages less than 1,000	7,062	7,238	9,069	10,019	11,574	13,324
Rural	142,599	140,582	154,829	167,931	187,889	244,356
Total Rural	162,524	163,207	180,961	195,954	225,152	286,869
Total Urban & Rural	484,288	638,807	771,078	795,777	897,317	1,066,305

[a] Population in the surrounding built-up areas is also included.

Since the route of the proposed Lake Erie-Ohio River Canal passes through the three basins, it is necessary to consider the probable effects the construction of this canal would have on the future economy of the area.

In providing the iron and steel industry in the Pittsburgh-Youngstown region with water-borne transportation for raw materials, the regional steel industry could improve its competitive cost position relative to the eastern and the Cleveland-Detroit steel-producing regions. Considering the importance of bulk transportation to the iron and steel industry, lower transportation costs made possible by construction of the proposed canal are expected to retard the projected decline in the proportion of the national steel production taking place in the Pittsburgh-Youngstown region and permit a long-term expansion in tons of steel produced.* Coal and raw materials for the iron and steel industry constitute the large tonnages that are used in or that move through the region. Construction of the canal would thus assist the basin in conserving its dominant industry. In regard to fostering the growth of diversified industries, the prospects appear less bright.

A comparison of 1960 employment in selected industries in counties along the Ohio River in Pennsylvania, Ohio, Indiana, West Virginia, and Kentucky with that in the U. S. (Table 7) shows the influence of the Ohio River waterway on employment.

---

*The proportion of national steel production in the economic study area is expected to decline because production is becoming more market oriented and less resource oriented. This change results from the increase in transportation costs for steel mill products relative to raw material transportation costs.

Table 7

Percent Employment in Selected Industrial Sectors
Ohio River Counties and the United States
1960

Industrial Sector	Ohio River Counties	United States
Manufacturing, Percent of Total Employment	31.8	20.0
Selected Industries, Percent of Manufacturing Employment		
Primary Metals	25.2	7.0
Fabricated Metals	7.9	7.4
Machinery, Except Electrical	7.1	9.0
Electrical Machinery	8.9	8.5
Chemicals	8.1	4.9
Total	57.2	36.8

In Table 8 the growth of employment between 1950 and 1960 in selected industries and manufacturing categories in the canal region and the river counties of the Ohio River system and tributaries (Ohio, Pennsylvania, Indiana, West Virginia, and Kentucky) is shown.

Table 8

Population and Employment Growth
Ohio River and Canal Counties
1950-1960

	Ohio River Counties percent change	Canal Counties percent change
Population	16.0	18.2
Total Employment	3.9	9.6
Manufacturing Employment	9.0	3.7
Primary Metals	-3.7	-1.8
Fabricated Metals	24.1	16.0
Furniture, Wood & Lumber Products	-15.5	-25.5
Other Durables	-6.5	-15.2
Food Products	14.0	47.6
Printing & Publishing	30.3	66.0
Textiles	-48.1	124.5
Apparels	3.1	-24.1
Chemical & Allied Products	38.8	40.4
Other Nondurables	8.3	-2.6

Two conclusions to be drawn from the comparison are that the canal region showed greater growth in terms of population and employment than did the river counties during the period and that the general pattern of growth in relation to employment by industry was not markedly dissimilar. Because of the lesser employment base in nonmanufacturing employment and, within the manufacturing category, in nonprimary metal manufacturing the increases and decreases in employment in the canal region are accentuated.

It appears that the economic effects of the proposed canal within the study area will be to bolster the regional steel industry but to make no

substantial contribution to industrial diversification in the region. In all probability, there will be an increased development of the chemical industry and some benefits for regional slag, cement, and limestone producers. There appears, however, to be little prospect for major industrial development based on production or use of regional natural resources considering the currect low level of activity in extractive operations.

The availability of inland water transportation seems of limited importance to industries not involved in producing or using large volumes of bulk materials. Thus, the effect of the proposed canal on the development of new, diverse manufacturing enterprises would tend to be minor.

Population Projections

Population projections for the Beaver, Mahoning, and Grand River Basins are presented in Table 9 and shown graphically on Figure III. Total population is estimated to reach 2,000,000 by 2010 and 3,300,000 by 2060. Compared with the projected increase of population in the United States, the population of the basins will increase at less rapid rate. The population of the study area is projected to increase at an average annual rate of 1.3 percent, while the projected United States population shows an average annual increase rate of about 1.8 percent. The urban sector of the population is expected to constitute an increasing percentage of total population: 80.1 percent by 2010 and 81.9 by 2060.

Table 9

Population Projections[a]
Beaver-Mahoning and Grand River Basins
1980-2060

Area[b]	1980	2010	2060
Beaver Falls-New Brighton	132	200	330
Youngstown-Niles-Warren	578	800	1,320
Painesville	51	80	165
Alliance	37	44	66
Sharon	80	114	188
Ellwood City	18	32	66
New Castle	73	120	231
Butler	44	60	100
Cities, 2,500 to 10,000	62	88	145
Total Urban	1,075	1,538	2,611
Villages, 1,000 to 2,500	37	46	69
Villages less than 1,000	16	18	23
Rural	336	398	597
Total Rural	389	462	689
Total Urban & Rural	1,464	2,000	3,300

[a] Population projections in thousands.

[b] Population in the surrounding built-up areas is also included.

VI. WATER SUPPLY REQUIREMENTS

Past and Present Water Uses

Municipal

As shown in Table 10 there is an estimated 96 mgd of municipal water supplies presently used in the Beaver-Mahoning and Grand River Basins. Municipal surface water supplies were found to be generally sufficient throughout the basins as measured in terms of quantity, but lacking in quality in some locations. Surface water quality impairment results from both municipal and industrial sources of pollution in the lower Mahoning River below Warren, Ohio. As a result, municipal supplies are no longer taken from this reach. Municipal water supplies for communities along this reach of the Mahoning River are principally taken from upland reservoirs. Public water supplies for the Youngstown-Niles area are supplied by a reservoir on Meander Creek, supplemented by a pipeline from Berlin Reservoir. The city of Warren takes its water supply from Mosquito Creek Reservoir.

Utilization of surface sources for water supply in the Grand River Basin is limited to a few small developments. Communities along the Lake Erie shore utilize the lake as a source of supply.

Except where dependence is on wells that are not adequate there are no municipal water shortages in the Beaver-Mahoning or Grand River Basins. Sources of surface supply are available and communities have been able to cope with the development problems.

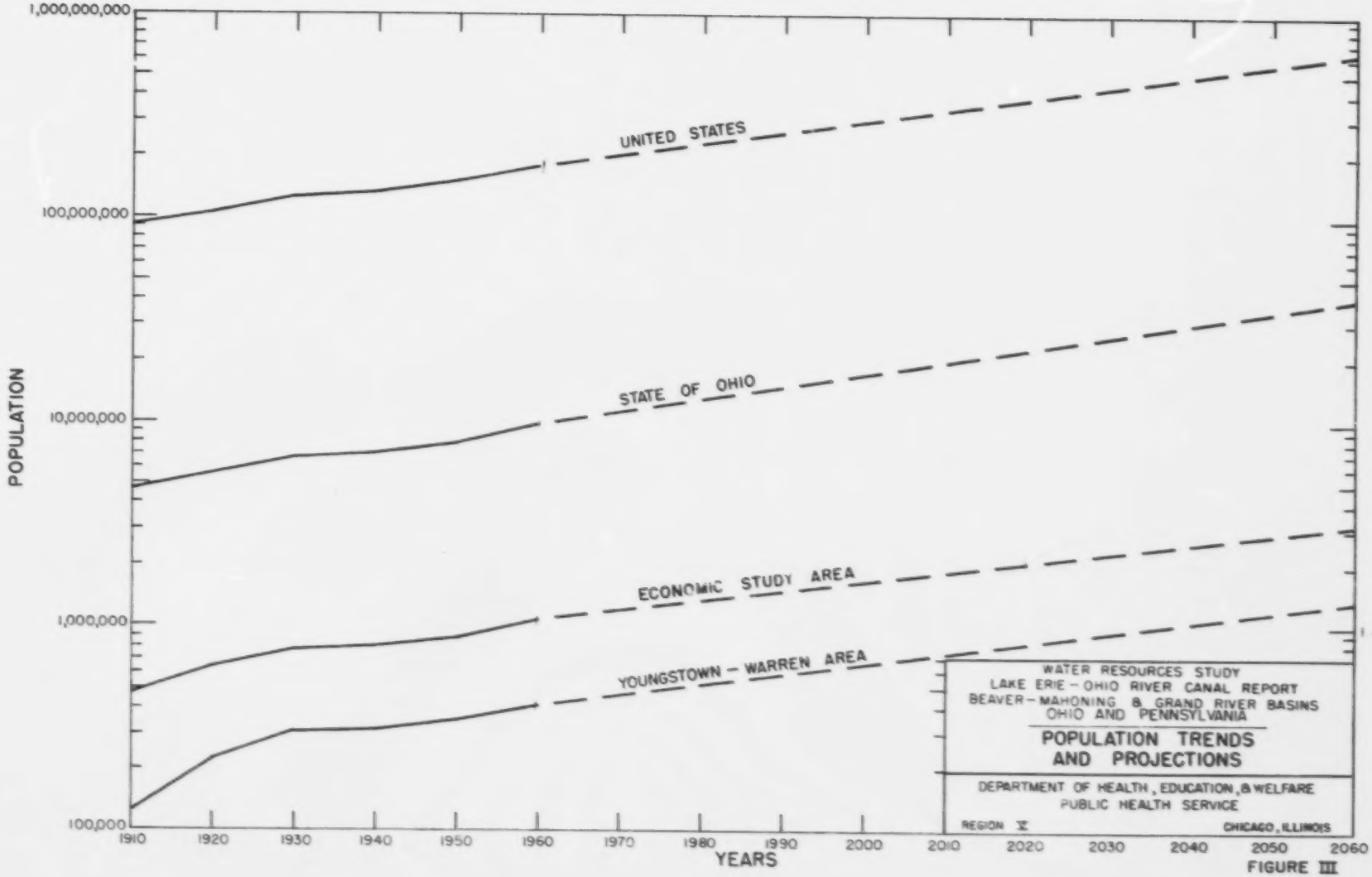

1,000,000,000
100,000,000
10,000,000
1,000,000
100,000
POPULATION
UNITED STATES
STATE OF OHIO
ECONOMIC STUDY AREA
YOUNGSTOWN - WARREN AREA
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
YEARS
WATER RESOURCES STUDY
LAKE ERIE - OHIO RIVER CANAL REPORT
BEAVER - MAHONING & GRAND RIVER BASINS
OHIO AND PENNSYLVANIA
POPULATION TRENDS
AND PROJECTIONS
DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION V
CHICAGO, ILLINOIS

FIGURE III

Table 10

Principal Municipal Water Supplies
Beaver-Mahoning and Grand River Basins

Community	Population 1960	Source	Average Use mgd	Est. Population Served
BEAVER-MAHONING RIVER BASIN				
Pennsylvania				
Beaver County				
Beaver Falls	16,240	Beaver River	4.2	35,000
Eastvale	513	Beaver Falls		
Fallston	410	New Brighton		
New Brighton	8,397	Beaver River	3.0	30,000
Butler County				
Butler	20,975	Connoquenessing Creek & Thorne Run	4.0	
East Butler	1,007	Butler		
Evans City	1,828	Likens Run & Wells	0.3	
Mars	1,522	Wells		
Slippery Rock	2,563	Wells	0.06	
Zelienople	3,284	Scholters Run	0.28	
Crawford County				
Linesville	1,255	Wells & Springs	0.05	
Mercer County				
Farrell	13,793	Shenango Valley Water Company	2.5	
Fredonia	657	Wells	0.06	
Greenville	8,765	Little Shenango River	0.75	
Grove City	8,368	Wells	0.7	
Jamestown	897	Springs & Wells	0.1	
Mercer	2,800	Otter Creek	0.3	
Sharon	25,267	Shenango Valley Water Company	4.7	
Sharpsville	6,061	Shenango River	0.94	
West Middlesex	1,301	Wells	0.05	
Wheatland	1,813	Shenango Valley Water Company	0.3	
Lawrence County				
Bessemer	1,491	Wells	0.6	
Ellwood City	12,413	Slippery Rock Creek	3.14	
New Castle	44,790	Shenango River	6.6	
New Wilmington	2,203	Springs & Wells	0.15	
Wampum	1,085	Wells	0.03	
Ohio				
Ashtabula County				
Andover	1,116	Wells	0.18	1,000
Columbiana County				
Columbiana	4,164	Wells	0.25	4,390
Mahoning County				
Beloit	877	Mahoning River	0.13	973
Campbell	13,406	McKelvey Lake	1.10	13,406
Canfield	3,252	MVSD	0.22	3,270
Craig Beach	1,139	Wells	0.090	1,880
Lowellville	2,055	OWSC	0.18	
Poland Village	2,004	[illegible]	0.22	
Sebring	4,439	Mahoning River	0.60	4,500
Struthers	15,631	OWSC	2.10	12,000
Youngstown	166,631	MVSD	31.0	250,000
Portage County				
Garrettsville	1,662	Wells	0.175	1,600
Hiram	1,011	Wells	0.115	1,200
Windham	3,777	Wells	0.17	4,808

Table 10 (Cont.)

Prinicpal Municipal Water Supplies
Beaver-Mahoning and Grand River Basins

Community	Population 1960	Source	Average Use mgd	Est. Population Served
Stark County				
Alliance	28,362	Deer Creek Reservoir	5.62	35,850
Trumbull County				
Cortland	1,957	Wells	0.12	1,957
Girard	12,997	MVSD	1.1	13,591
Hubbard	7,137	Wells	0.65	7,200
Masury	2,512	Shenango River	0.20	2,151
McDonald	2,727	MVSD	0.63	2,782
Newton Falls	5,038	Mahoning River	0.90	5,230
Niles	19,545	MVSD	3.0	19,571
Warren	59,648	Mosquito Creek Reservoir	9.00	70,000
GRAND RIVER BASIN				
Ohio				
Ashtabula County				
Geneva	5,626	Grand River	1.02	5,626
Jefferson	2,116	Mill Creek	0.250	3,000
Orwell	819	Wells	0.06	903
Geauga County				
Chardon	3,154	Wells	0.44	3,600
Lake County				
Madison	1,347	Wells	0.11	1,350
Painesville	16,116	Lake Erie	2.98	16,115
Perry	885	Wells	0.04	885
Trumbull County				
West Farmington	614	Wells	0.24	608
Total			95.85	

MVSD = Mahoning Valley Sanitary District, sources of supply are Berlin and Meander Creek Reservoirs.

OWSC = Ohio Water Service Company, sources of supply are small impoundments on Yellow Creek.

On the lower Beaver River the Beaver Falls Municipal Authority and New Brighton pump an average of 7.2 mgd of water from pools formed by low head dams on the main stem of the Beaver River to serve a population of about 65,000. Severe water treatment problems have resulted from obtaining water supplies from this source as a result of the waste loads discharged upstream on the Mahoning River.

Municipal systems provide considerable industrial sanitary and process water as indicated on Tables 11 and 14. The data differ somewhat since they are from different sources and a slightly different definition of "public supplies" has apparently been used. However, total water use is essentially the same. Based on data presented in Table 11, 28.2 mgd of industrial water is supplied by municipal systems.

Table 11

Industrial Water Use by Major Firms[a]
Beaver-Mahoning and Grand River Basins
1959

Basin	Number of Firms	Number of Employees	Water Use[a] by Source, mgd				
			Public Supplies	Wells	Inland Surface	Lake Erie	Total
Mahoning[b]	361	81,900	28.20	1.90	1,049.06	-	1,079.16
Grand[c]	61	7,800	0.23	0.03	-	119.07	119.33

[a] Includes public utility and private electric power plants.
[b] See Appendix B for breakdown by communities.
[c] All industrial use in the Grand River Basin occurs in the Painesville area.

Industrial

Industries in the Mahoning River Basin use relatively large quantities of surface water (see Tables 11, 12, 13, and 14). The largest use is for industrial cooling purposes in the production of basic iron and steel in the Youngstown area between Warren and Lowellville, Ohio. Industrial use of river water by the principal firms in this reach of river in excess of 1,500 million gallons per day occurs during full production periods. Average use is estimated at 1,080 mgd of which about 1,036 mgd is for cooling water use in the Youngstown-Warren area. Thus in the order of 43.4 mgd is for sanitary and process use purposes of which about 15.2 mgd is privately supplied. As the average annual flow of the Mahoning River at Youngstown is less than the industrial use in that area, it can be seen that reuse of streamflow is very high at certain periods.

Table 12

Cooling Water Use from Mahoning River
Major Industries in the Youngstown-Warren Area 3/

Community	Use, mgd
Warren	215.032
Niles	76.325
McDonald	56.000
Girard	0.580
Hubbard	0.102
Youngstown	615.792
Lowellville	72.000
Total	1,035.831

Table 13

Industrial Water Use in Ohio
Beaver-Mahoning and Grand River Basins 3/
1959

Industry	Water Use by Basin, mgd	
	Grand	Mahoning
Primary Metals	0.001	845.874
Public Utilities	-	215.053
Chemicals	84.238	0.513
Textiles	35.001	0.010
Fabricated Metal	0.013	9.304
Electrical Equipment	0.002	1.638
Transport Equipment	0.007	0.220
Rubber	0.028	1.152
Machinery	0.008	2.661
Food & Kindred Products	0.001	0.662
Stone, Clay, etc.	0.001	0.517
Paper & Allied Products	0.009	0.134
Miscellaneous	0.015	1.418
Total	119.324	1,079.156

Table 14

Industrial Water Use[a/]
Mahoning River Basin, Ohio
1959

Community	County	Sources, mgd			
		Municipal	Wells	Surface	Private Water Company
Columbiana	Columbiana	0.023	0.109		
Beloit	Mahoning		0.034		
Campbell	"	0.046			
Canfield	"	0.053			
Lowellville	"	0.036		72.000	
Sebring	"	0.041			
Struthers	"	0.006			
Youngstown	"	6.294	0.455	615.792	19.449
Garrettsville	Portage	0.011	0.028	0.725	
Ravena	"		0.100		
Windham	"		0.016		
Alliance	Stark	2.743	0.053		
Cortland	Trumbull		0.001		
Girard	"	0.034	0.220	0.580	
Hubbard	"	0.033	0.040	0.102	
McDonald	"	0.500	0.002	56.000	
Newton Falls	"	0.890		1.276	
Niles	"	5.774		76.325	
Warren	"	4.848	0.863	215.032	
Totals		21.332	1.921	1,037.832	19.449

(Total supply, all sources, is 1,080.534 mgd)

[a/] From "Water Inventory of the Mahoning and Grand River Basins," Report No. 16, State of Ohio Division of Water.

Cooling water supply requirements depend on the level of production and the amount of off-stream cooling provided. Consumptive losses were estimated by the Ohio Department of Water Resources to amount to about 34 mgd.

Additional Water Supply Needs

Municipal

Since municipal water supplies for the Warren-Niles-Youngstown area are secured from upstream storage reservoirs, canalization of the Mahoning River will have no adverse effect on existing supplies. It is anticipated that the present pattern of water use will continue and future supplies will be obtained from above the Youngstown industrial complex.

Municipal water supplies obtained from the lower Beaver River should be improved by the greater detention time resulting from increased channel depth, although this will be partly offset by the increased flow needed to maintain water quality in the Youngstown area.

Based on future population set forth in the economic section and anticipated water use rates, estimated future water use at major communities in the Beaver-Mahoning and Grand River Basins is shown in Table 15. Except where present use is at a greater rate it was assumed that municipal water use would increase to at least 140 gpcd by 1980, to 165 gpcd by 2010, and to 175 gpcd by 2060. Approximately 40 percent of the total population of the two basins is located in the Youngstown-Warren area and it is expected that this area will continue to be the major center of population in the basin in the future. In this area current water use amounts to 152 gpcd and is ex-

pected to increase to at least 175 gpcd by 1980, to 200 gpcd by 2010, and to continue at that figure thereafter. Projected municipal water supply requirements consider the total needs of all the communities within each area rather than individual community needs. The projections in Table 15 cover all municipal water needs and include commercial and industrial needs for sanitary and process purposes.

The Youngstown-Warren area appears to be the most critical in terms of future needs. The Mahoning Valley Sanitary District's Meander Creek Reservoir can supply an estimated 30 mgd and the addition of Berlin Reservoir increased the dependable supply to about 64 mgd. Water supply storage in Mosquito Reservoir provides the Warren area about 16 mgd. The Ohio Water Service Company has eight reservoirs on Yellow Creek, Dry Run, and Squaw Creek that can supply an estimated 27 mgd, although less than 10 percent of this is sold for municipal use. Small reservoirs in the area can supply an additional 2 to 4 mgd.

The total capacity of these sources can meet projected needs through about 1980 for the Youngstown-Warren area. Additional sources will be needed to provide 50 mgd to meet water supply requirements through year 2010. To meet water supply needs through 2060 will require an estimated 154 mgd of added supply. Although the surface water runoff is relatively highly regulaged and upstream reservoir sites are limited, undeveloped sites exist that could be utilized to meet water supply needs in the Youngstown area.

Table 15

Projected Municipal and Industrial Water Use,[a] mgd
Beaver-Mahoning and Grand River Basins

Water Use Area[b]	Year			
	1960	1980	2010	2060
Beaver Falls-New Brighton	7.2	18.2	33.4	57.7
Youngstown-Niles-Warren	63.7[c]	101.0	160.0	264.0
Painesville	2.98	7.2	13.2	28.8
Alliance	5.62	6.2	7.4	11.5
Sharon	7.50	11.2	19.0	33.0
Ellwood City	3.14	3.5	5.4	11.6
New Castle	6.6	10.2	20.0	40.5
Butler	4.0	6.1	10.0	17.5
Cities with less than 10,000 population	10.26	12.4	14.6	25.4
Total	111.0	176.0	283.0	520.0

[a] Exclusive of cooling water use.

[b] Population in the surrounding built-up areas is also included.

[c] Includes 48.55 mgd supplied through municipal systems and 15.2 mgd self-supplied industry.

Industrial

The major industrial use of the Mahoning River is for cooling water purposes. Canalization will reduce the rate of heat loss at the water surface but will provide a compensating increase in time of flow between heat sources. The increased flow necessary for water quality control will reduce water temperatures and result in more uniform water quality.

As indicated above allowance for sanitary and process water needs has been made in municipal water use figures. As previously covered, before Berlin and Mosquito Creek Reservoirs were built, river temperature at Youngstown reached as high as 130°F when streamflows were less than 40 cfs. Flow regulation has been provided by these reservoirs to prevent such extremely high temperatures, although it is estimated that temperatures may still rise to about 112°F for periods up to a week in duration in the summer season if steel mills are operating at about 85 percent of capacity.

Cooling water supply needs depend on the amount of off-stream cooling provided and consumptive losses in the cooling towers. The State of Ohio[3/] has estimated that consumptive losses amounted to about 34 mgd in 1960. A combination of available flow regulation and additional off-stream cooling can provide cooling capacity necessary for anticipated industrial water use for cooling purposes.

Based on a continuing program of water conservation and extension of water reuse practices, no additional industrial water supply storage for cooling water purposes is considered to be necessary at this time. Detailed consideration of industrial water use practices in the iron and steel industry

in connection with the Ohio River Basin Project may require revision of this conclusion but a review of industrial water use in other areas of the country and potential process modifications indicates that presently available supplies can satisfy anticipated industrial water supply needs from the Mahoning River.

VII. WATER QUALITY CONTROL

Sources of Pollution

Municipal

Appendix A indicates the estimated sewered population, treatment, and receiving stream for municipalities in the Beaver-Mahoning and Grand River Basins. While a substantial number of communities provide treatment, large quantities of municipal sewage are discharged to streams with no treatment. It is estimated that municipal wastes presently reaching the Youngstown-Warren reach of the Mahoning River are equivalent to raw sewage contributed from a population of about 170,000 persons.

Industrial

The quality of water in the Youngstown-Warren area has been improved by flow regulation made possible by Berlin and Mosquito Creek Reservoir; however, quality conditions still are unsatisfactory.

Appendix B provides data on industrial waste sources.

Aside from organic waste loads from both municipal and industrial sources in the Mahoning and Beaver Rivers, many firms release waste water containing toxic metals, acids, etc., the magnitude of which is not expressable in terms of population equivalents as are organic wastes. This type of waste results from processing operations at steel mills, plating works, blast furnace installations, and some metal fabricating establishments.

There are five industrial thermal electric power plants on the Mahoning River: two at Youngstown and one each at Warren, Campbell, and Hubbard. In addition, there are public utility plants at Warren, Niles, and Lowellville. Over 2 billion kwh are produced annually by these eight plants. In general, industrial cooling water is used and returned to the stream without much change in quality except for increased temperature and increased consumptive losses through increased evaporation. The high percentage of water reused in the Mahoning River, twice the annual average streamflow, not only intensifies the effects of river pollution but substantially increases production costs. Increased flow regulation would tend to offset some of these detrimental thermal effects and would be of definite economic value to industry and for quality control purposes in general.

Surface Water Quality

The Pennsylvania State Health Department conducted a water quality investigation of the lower Mahoning, Shenango, and Beaver Rivers from 1959 to 1961. The locations of the sampling stations are shown in Figure IV. Samples were collected at each station on a monthly basis from September 1959 through September 1961. Table 16 contains a summary of the findings of most importance to water quality in this study. These data are felt to represent current quality conditions.

Table 16

Surface Water Quality
Beaver-Mahoning and Shenango Rivers in Pennsylvania
September 1959-September 1961

Station[a/]	D.O., mg/l			Coliform, MPN/100 ml		Phenol, mg/l			Alkalinity, mg/l			Total Iron, mg/l		
	Avg.	Max.	Min.	Avg.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.
1	6.6	11.0	4.4			0.015	0.10	0	70	120	32	1.6	3.4	0.2
2	4.9	13.8	1.8	11,000,000	230	0.029	0.10	0	72	110	44	3.5	16.0	0.2
3	4.8	13.2	1.3	4,600,000	9,300	0.038	0.15	0	72	115	44	3.0	20.0	0.3
4	8.3	15.8	4.6			0.020	0.10	0	71	125	32	1.2	2.8	0.5
5	5.7	13.3	2.0			0.020	0.15	0	69	115	44	1.8	8.4	0.2
6	7.3	13.6	4.1			0.006	0.10	0	70	126	32	1.0	3.4	0.2
7	7.8	10.6	4.1			0.035	0.30	0	65	110	34	1.5	8.0	0.3
8	8.5	10.9	5.0	1,100,000	230	0.028	0.30	0	65	110	32	1.4	5.0	0.2

a/ See Figure IV for location of sampling stations.

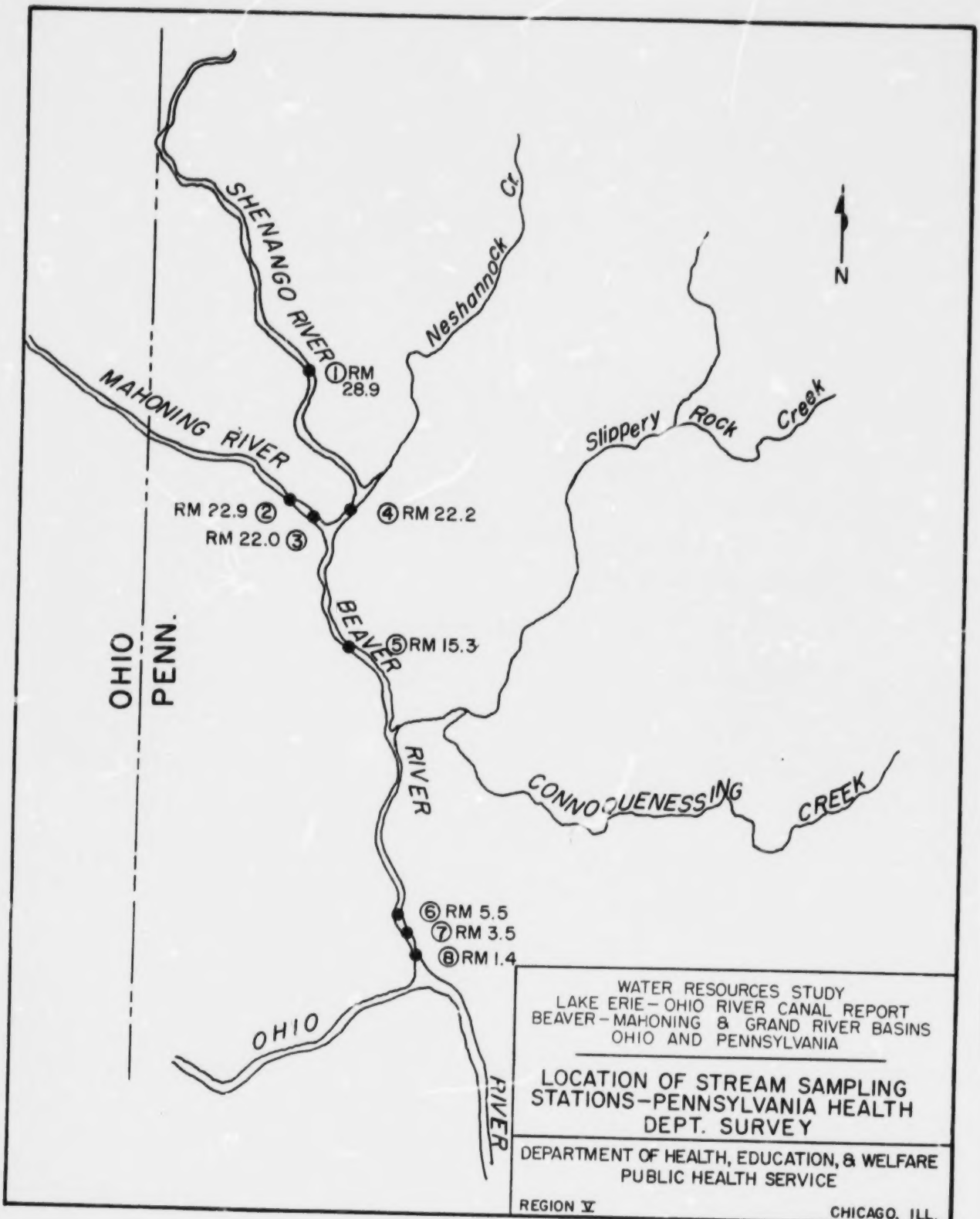

SHENANGO RIVER
① RM 28.9
Neshannock Cr.
MAHONING RIVER
RM 22.9 ②
RM 22.0 ③
④ RM 22.2
Slippery Rock Creek
OHIO
PENN.
BEAVER
⑤ RM 15.3
RIVER
CONNOQUENESSING CREEK
⑥ RM 5.5
⑦ RM 3.5
⑧ RM 1.4
OHIO
RIVER
N
WATER RESOURCES STUDY
LAKE ERIE – OHIO RIVER CANAL REPORT
BEAVER – MAHONING & GRAND RIVER BASINS
OHIO AND PENNSYLVANIA
LOCATION OF STREAM SAMPLING STATIONS – PENNSYLVANIA HEALTH DEPT. SURVEY
DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION V
CHICAGO, ILL.

FIGURE IV

Water Quality Objectives

The quality of water determines the uses that can be made of it, and unless the quality is maintained to a reasonable extent, possible economic benefits of its use will be lost and the public health may be endangered. Until fairly recently, major emphasis has been placed on the problem of sewage pollution, initially because of the relation to water-borne enteric disease and later because of the effects of organic pollution on streams and aquatic life. As areas become increasingly industrialized, the contribution of water-borne industrial wastes to quality degradation has grown in importance.

The evolution of quality conditions in the Beaver-Mahoning and Grand Rivers has been based on a consideration of the objectives, standards, and criteria which have been used by the U. S. Public Health Service and by various State and interstate agencies in the past in evaluating pollution conditions. The primary responsibilities and rights of the States involved in preventing and controlling water pollution have been the basis for placing particular emphasis on the standards of quality which have been applied by them on these streams.

Considering the purpose of the Water Pollution Control Act, which is to maintain and improve water quality so that it can be used and reused for municipal and industrial purposes and yet maintain recreational and aesthetic uses for the general well-being of people, this report has been based on the maintenance of conditions so that preservation of aquatic life may be possible. Major

pollutants from the area are organic materials and heat. While it is not contemplated that the Mahoning River will be reused for municipal purposes in the immediate Youngstown area, reuse for various industrial purposes will be possible, adverse effects on the stream will be minimized, and instream uses will be preserved if a concerted program of municipal and industrial waste collection, treatment, and flow regulation is undertaken. Investigations by the Public Health Service in the Cincinnati area have shown that a well-rounded fish population can be maintained only where the dissolved oxygen concentration is continuously above 3 mg/l and below 5 mg/l no more than 16 hours per day.[8/] Therefore, streamflow needs have been based on the maintenance of a daily average of at least 4 mg/l of dissolved oxygen.

Both the State of Ohio and the State of Pennsylvania have established objectives as to the minimum dissolved oxygen concentration which should be allowed in their respective streams. For the Grand River and for the Mahoning River above Warren, Ohio, the State of Ohio has established 4 mg/l as the minimum acceptable concentration at the design flow. The State of Pennsylvania has established the same objective for the Mahoning, Shenango, and Beaver Rivers. Recognizing that heat and other pollutants discharged to the reach from Warren, Ohio, to below Youngstown, Ohio, would prevent the maintenance of desirable aquatic life in the stream, the State of Ohio has allowed a minimum D.O. of 3 mg/l down to the State line. This concentration is expected to prevent excessive nuisance conditions even though it may not maintain fish life. The Aquatic Life Advisory Committee of the Ohio River Valley Water Sanitation Commission (ORSANCO) recommended that "the dissolved oxygen content

of warm water fish habitats shall be not less than 5 p.p.m. during at least 16 hours of any 24-hour period. It may be less than 5 p.p.m. for a period not be exceed 8 hours within any 24-hour period but at no time shall the oxygen content be less than 3 p.p.m. To sustain a coarse fish population the dissolved oxygen concentration may be less than 5 p.p.m. for a period of not more than 8 hours out of any 24-hour period but at no time shall the concentration be below 2 p.p.m."

A review of the literature on the effects of abnormally high water temperatures on aquatic life indicates that fish can temporarily survive temperatures of 93°F, but that with prolonged exposure to such abnormal temperatures, drastic and severe changes will occur in the aquatic biota. Sudden changes in water temperatures of 9°F or more may also adversely affect fish life.[8/] Considering the effect of elevated temperatures on metabolic rates of fish, the minimum dissolved oxygen concentration contemplated and the possible presence of toxic waste constituents, a maximum summer water temperature of 93°F has been selected as the basis for thermal treatment measures and flow regulation needs.

Various water quality objectives have been proposed for streams receiving heated effluents. The State of Pennsylvania has established maximum allowable temperatures,[4/] depending on existing or proposed uses of streams. The maximum allowable temperature in the Mahoning-Beaver River in Pennsylvania has been established as 93°F. Ohio has not established temperature objectives for the Mahoning River. The Aquatic Life Advisory Committee of the Ohio River

Valley Water Sanitation Commission recommends that in order to maintain stream conditions capable of producing an annual harvestable fish crop, waste discharges should be controlled so that the temperature of the receiving water should not be raised above 34°C (93°F) at any place or at anytime, nor raised above 23°C (73°F) during the months of December through April.

Chemical pollutants from industrial processes should be kept below toxic levels after treatment and dilution in the stream as set forth in the Public Health Service Drinking Water Standards. Phenolic wastes have been discharged in the past and concentrations in the Mahoning River should be rediced to 0.001 mg/l after dilution in the stream and treatment at the next point of water supply use so that taste and odor problems do not develop. Phenol concentrations in the Mahoning River have not been used as a basis for streamflow regulation requirements. No stream quality criteria have been established by either Ohio or Pennsylvania. However, South Carolina and New York limit pehnols to 0.005 mg/l, while North Carolina has established a limit of 0.003 mg/l for raw water to be provided complete treatment. The Aquatic Life Advisory Committee of the Ohio River Valley Water Sanitation Commission has recommended that the concentration of phenolic substances be kept below 0.05 mg/l in the receiving water.

Numerous chemicals for insect sprays, weed control, and other agricultural purposes have been developed in recent years. Some investigators feel that these chemicals, which are extremely toxic to aquatic life and constitute a potential hazard to humans, should be limited in the river to

protect aquatic life and at water intakes to protect municipal users. However, data available at this time are inadequate to establish minimum levels for separate constituents. A general limitation on the introduction of hazardous organics has been added to the recent revision of the Public Health Service Drinking Water Standards for Interstate Carriers. Chloroform extractables are limited to 0.2 mg/l. With development of industry in the Mahoning River Valley, the particular chemicals used may change radically so that continual evaluation will be necessary. It is felt that the objectives used in this study are in reasonable agreement with the objectives of the States and of the Ohio River Valley Water Sanitation Commission.

Temperature

Canalization of Mahoning and Beaver Rivers should have no appreciable effect on the capacity of the Mahoning River to dissipate heat that is introduced through industrial use because this capacity is directly proportional to the surface area of the stream. Since the canalized stream network will not significantly increase the water surface area, the heat losses will not change appreciably. LeBosquet reports[5] that if the surface area and the streamflow are not changed it makes little difference whether the stream is 2- or 20-feet deep. In the deep river the volume of water to be cooled will be much greater, but the time of flow between points of use will be correspondingly increased. This has considerable to do with the form of heat losses, whether by radiation or convection. If mixing is not complete then the proportion of the heat lost by evaporation may be increased.

The ability of the Mahoning River to dissipate heat loads will increase by the provision of increased streamflow. Benefits to industry resulting from the provision of various flow schedules are estimated in this report.

Flow Regulation Needs

Beaver-Mahoning River

The proposed canal will transform the Beaver-Mahoning River from a relatively swift, free-flowing river system to a series of quiescent pools with velocities one-tenth or less than those previously recorded during low flow periods. The decreased velocity shown in Figure V will cause increased sludge deposition and decreased bottom scouring during high flows. Of even more importance is the reduction in the rate of surface reaeration resulting from decreased streamflow velocities and water turbulence. To determine the relative order of magnitude of these detrimental effects on the ability of the streams to assimilate organic waste loads and realize water quality objectives, a thorough examination of the more significant factors has been made. This necessarily involved consideration of pertinent physical changes that have been made since the 1947 report[5] plus the modified effect of changes in basic benefit evaluation concepts pertaining to flow regulation from multipurpose storage reservoirs.

According to the Corps of Engineers, reservoirs in the Mahoning River Basin are presently being operated so that average monthly flows will be at least as great as those shown in Table 17.[6/7] By use of temperature-discharge

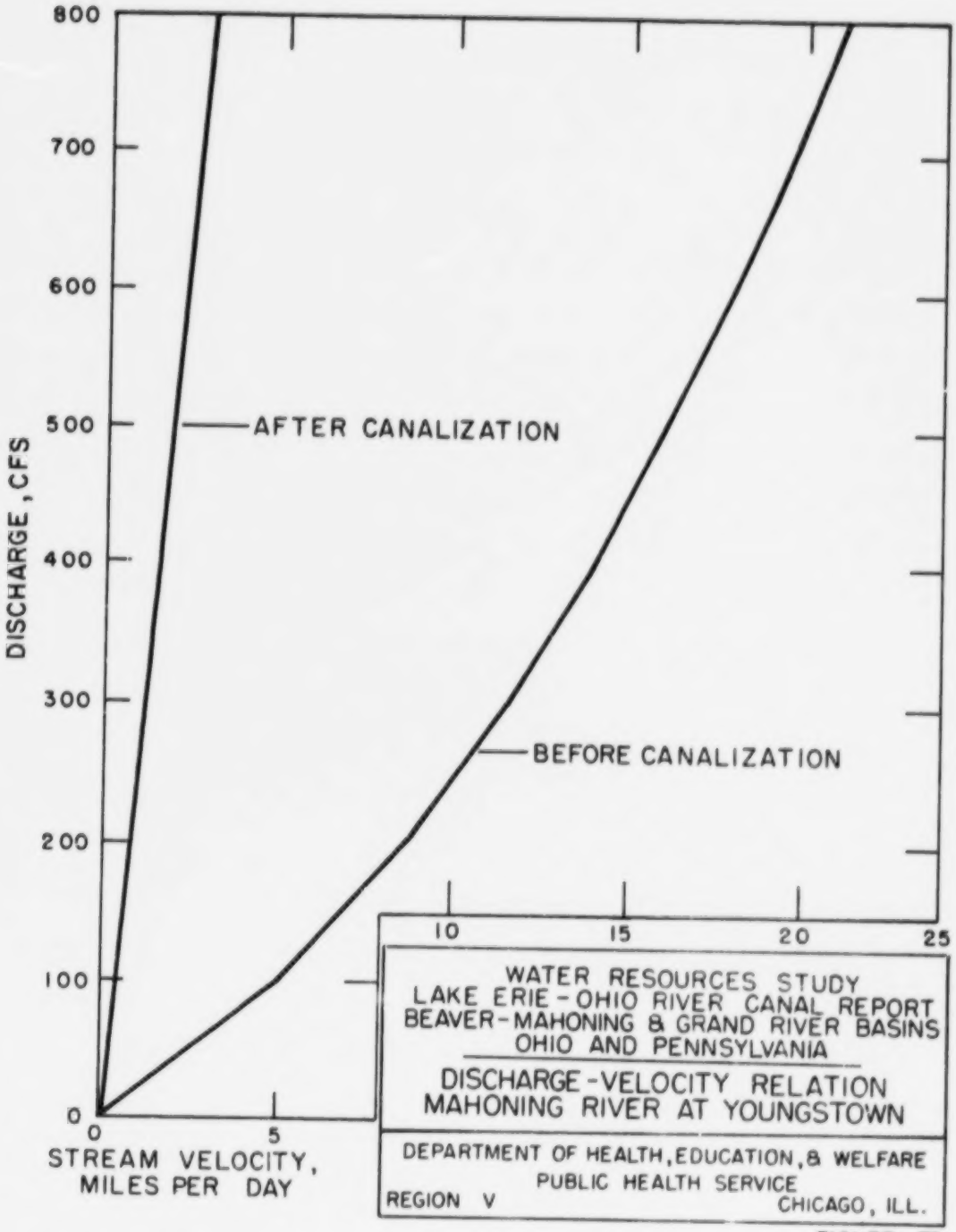

800
700
600
500
400
300
200
100
0
DISCHARGE, CFS
AFTER CANALIZATION
BEFORE CANALIZATION
0
5
10
15
20
25
STREAM VELOCITY,
MILES PER DAY
WATER RESOURCES STUDY
LAKE ERIE - OHIO RIVER CANAL REPORT
BEAVER - MAHONING & GRAND RIVER BASINS
OHIO AND PENNSYLVANIA
DISCHARGE - VELOCITY RELATION
MAHONING RIVER AT YOUNGSTOWN
DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION V
CHICAGO, ILL.

FIGURE V

Table 17

Regulated Discharge
Mahoning River at Youngstown

Month	Minimum Average Regulated Discharge, cfs		Average Air Temperature °F
	Present Regulation	With West Branch Reservoir	
January	185	225	30
February	185	220	29
March	185	230	38
April	202	310	48
May	295	410	60
June	413	480	69
July	470	520	73
August	425	515	71
September	333	500	65
October	235	410	54
November	185	330	42
December	185	225	32
Average	275	365	

River temperature is estimated by adding excess temperature from Figure II for a given discharge condition to the average monthly air temperature (assumed to approximate the natural river water temperature) shown above.

data shown in Figure II, flow requirements were derived to meet the stream quality objectives under natural and canalized conditions. This also involved estimating present and future organic waste loads that will reach the stream as effluent from secondary (biological) waste treatment facilities located throughout the waterway network and making reasonable allowances for uncontrolled sources of waste. Provision of adequate treatment has been assumed to provide at least 85 percent removal of first-stage BOD. The State of Ohio has required secondary treatment on tributary streams in the Mahoning Basin but has recently approved construction of primary treatment on the lower Mahoning. Considerable effort has been expended on reduction of phenol discharges but the effective level of industrial waste treatment provided at this time is not known. A critical examination of data on organic waste discharges and cooling water use makes possible the derivation of flow schedules to meet varying conditions of velocity and temperature and provide for meeting the stream quality objectives. Table 18 shows the results of these calculations for present and canalized conditions. Actual releases should be based on frequent observations of water quality in the Youngstown area. It is significant to note that the canalized flow schedule required to meet present quality control needs under canalized conditions will exceed the 2010 uncanalized requirements.

Additional flows needed to maintain equivalent waste assimilation capacity in the Mahoning River after canalization require an average increase in the critical flow schedule of 206 cfs. To maintain the present assimilative capacity will require increasing the minimum desirable average canal flow schedule from 387 cfs to 584 cfs.

Table 18

Streamflow Requirements for Quality Control
Mahoning River at Youngstown

Month	Required Streamflow Uncanalized, cfs				Required Streamflow Canalized, cfs			
	1960	1980	2010	2060	1960	1980	2010	2060
January	240	290	350	500	320	410	500	670
February	245	305	355	505	330	420	510	700
March	260	350	410	550	400	470	570	800
April	390	440	520	650	510	610	710	950
May	490	550	650	820	650	750	870	1,080
June	515	710	805	990	880	950	1,030	1,220
July	515	710	850	1,030	930	1,000	1,100	1,300
August	515	710	805	970	880	950	1,030	1,220
September	515	610	700	880	730	840	910	1,130
October	390	440	520	650	510	610	710	950
November	310	360	430	600	420	510	610	850
December	260	310	370	510	350	440	530	730
Avg.	387	480	565	723	584	663	756	966

Grand River

Painesville, Ohio, located at the mouth of Grand River takes water supplies from Lake Erie and discharges the resulting waste waters to the Grand River. Painesville had a population of 16,116 in 1960. On the basis of past trends and estimated future potential, the population is expected to reach 51,000 by 1980, about 80,000 by 2010, and 165,000 by 2060. These figures are not unreasonable for a community along the banks of the Great Lakes and in the near proximity of the Cleveland, Ohio, industrial complex. With growth of this magnitude, it is doubtful that Painesville would continue to discharge all of its wastes to the Grand River in lieu of Lake Erie. Streamflow requirements for quality control in the Grand River were based on estimated sewered populations of about 22,000 by 1980, 33,000 by 2010, and 67,000 by 2060.

Present plans call for canalizing the Grand River with three locks and dams from Lake Erie to Summit Reservoir. Immediately east of Painesville at the mouth of the Grand River, the canal will depart from the present river bed and connect to Lake Erie by a cut-off canal. The portion of the Grand River passing through Painesville that will not be canalized is the reach presently receiving wastes from the Painesville area.

Operating plans call for storing a maximum of 65,000 acre-feet from the Grand River Basin in Summit Reservoir. It is estimated that storage will provide for an outflow of 200 cfs into Lake Erie in drought years plus the runoff from about 150 square miles of drainage area that lie between the reservoir and the lake. The navigation plan proposed by the Corps of Engineers

will require supplemental pumpage for lockage purposes, with pumping stations located at each of the dam sites.

The following quality control flows are considered the minimum that will be needed in the reach of the Grand River below the canal diversion:

Quality Control Flows, cfs

	1960	1980	2010	2060
Summer	20	25	55	90
Spring and Fall	15	20	40	65
Winter	10	15	25	40
Mean	15	20	40	65

The minimum flow presently considered available for waste assimilation purposes in the lower Grand River, the 7-day mean streamflow with a recurrence interval of once in 10 years, is 28 cfs. The time of first need would therefore be about 1990. It is estimated that by 2010 a draft on storage of 7,500 acre-feet will be needed to maintain the above flow schedule at Painesville. By 2060 this will increase to about 20,000 acre-feet to maintain acceptable water quality.

There are no significant amounts of waste presently reaching the future canalized portion of the Grand River. The future of this area along the canal in terms of the waste loads that might originate there has not been evaluated. This reach of the river is not presently developed and the future of this area, considering the availability of industrial sites along the Lake Erie shore, is uncertain, making projections difficult and the estimation of needs for future quality control flows even more so. If significant volumes of treated waste discharges are released to the canal with presently planned

minimum flows and with the further possibility of back pumpage for lockages, extremely poor water quality could be expected. It is not possible to estimated the flows that would be required in the impounded reaches of the canal at this time but it is felt that they could be considerable. It is therefore probable that wastes from this area should be collected and discharged, after adequate treatment, to Lake Erie.

VIII. BENEFITS OF STORAGE

The Lake Erie-Ohio River Canal project will provide a navigation link between the inland waterways of the upper Ohio River and the Great Lakes which can be used by boating enthusiasts in addition to commercial shipping. Summit Reservoir will cover about 70,000 acres during the summer season which will improve the aesthetics of the area and its very existence will increase property values in the vicinity of the lake. This project will do much to enhance the recreational opportunities of the study area.

Conservation storage in Summit Reservoir can make water of good quality available for municipal and industrial purposes and improve the quality of the Mahoning River for instream and withdrawal uses.

Water Supply

Beaver-Mahoning River Basin

Municipal and associated industrial water use in the Youngstown-Warren area is expected to increase to about 160 mgd by 2010 (see Table 15). This represents an increase of about 50 mgd over presently available supplies. Allocation of storage in Summit Reservoir to water supply use would have a value at least as great as the cost of a single-purpose reservoir of the same yield constructed in 1980 when the capacity of existing sources is reached. Although the number of storage sites in the Mahoning River Basin is limited, there are sites which could be developed for this purpose.

A single-purpose reservoir in this area to yield 50 mgd on a year-round basis should have capacity to store about 75,000 acre-feet which includes allowances for siltation, evaporation, and other losses. It is estimated on the basis of generalized cost figures for this area that this reservoir would cost in the order of $17,000,000 to construct and $40,000 per year to operate and maintain. Considering the topography such a site should be available. However, present land use may preclude certain sites and a more refined estimate should be made in final project evaluation. Using a 4 percent municipal interest rate, these costs were amortized over a 30-year bonding period (1980-2010). Annual bond payments and operating costs were then capitalized and discounted to 1960 at 3 percent interest (the current Federal rate) to obtain the present worth. This amount was then amortized over 100 years at 3 percent resulting in an average annual value of $357,000 over the life of the project.

Provision of about 210,000 acre-feet of storage to yield 154 mgd to meet 2060 needs are estimated on the same basis to have an average annual value of $757,000 over the life of the project.

While it is recognized that higher pool levels provided by canalization should reduce pumping costs for industrial cooling water supplies, the savings will depend on the location of the major withdrawals and have not been evaluated.

Grand River Basin

Geneva, Ohio, presently draws about 1 mgd of surface water from the Grand River. Geneva is outside the Grand River Basin, lying between Grand River and Lake Erie. A low head impoundment provides the storage needed to satisfy future needs through the study period. This impoundment and associated

intake facilities will be inundated by Summit Reservoir. Continued use of the Grand River Summit Reservoir as a source for water supply will not result in a benefit to Geneva since its supply was already adequate for its anticipated needs. The water used by Geneva is discharged to a stream tributary to Lake Erie which results in a net reduction in flow in the Grand River to the extent of the supplies withdrawn.

Water Quality Control

Both tangible and intangible benefits will result from provision of storage in Summit Reservoir for water quality control in the Beaver-Mahoning-Grand River Basin.

Evaluation of water quality control needs in such a highly industrialized area as the Beaver-Mahoning-Grand River Basin and with such a radical change in hydraulic regimen as will result from canalization is extremely complex. While many quality factors are affected, consideration of the combined effects of organic and thermal wastes on dissolved oxygen concentrations and on temperature in the Mahoning River in and below the Youngstown-Niles-Warren area has been the basis for evaluation of storage needs for water quality control.

The estimated water supply and quality control benefits reported herein are considered reasonable for project evaluation, but should be considered tentative pending completion of comprehensive studies presently being conducted by the Public Health Service in the Great Lakes and Ohio River Basins. Collection of field data on waste sources, stream characteristics, and water

uses will make possible more detailed analysis permitting more refined estimates of benefits.

Together with adequate treatment of wastes, flow regulation will contribute to the aesthetic enjoyment of clean water in the Beaver-Mahoning and Grand Rivers. Increased flows will also contribute to improved water quality in the Ohio River although these benefits can not be separately enumerated since water quality control flow needs have not be determined.

Beaver-Mahoning River Basin

Extremely poor quality conditions would be expected to occur frequently in the absence of adequate treatment or control of industrial wastes at their source and additional flow regulation and would result in occasional fish kills or the elimination of aquatic life from the area. Adoption of adequate treatment for all municipal and industrial wastes in the Youngstown-Niles-Warren area together with regulation of flows as set forth in this report can assure dissolved oxygen concentrations of 4 mg/l or above and temperatures of 93°F or below over 55 miles of the Beaver-Mahoning River from Warren to the mouth of the Beaver River. Maintenance of acceptable conditions in the Youngstown area will permit the movement of fish through the area when necessary in various stages of their life cycle, contributing to the fishery over a considerably wider area.

Regulation of flow in addition to adequate treatment will reduce the concentration of residual organic and inorganic wastes resulting from municipal and industrial use, thereby improving the quality for industrial reuse, limiting slime control measures that may be needed, reducing the corrosiveness

of the water or allowing savings on the preconditioning that may be provided in the Youngstown area. The effect of heat loads on subsequent cooling use will be decreased.

The availability of water of assured quality will reduce water treatment costs at existing industrial plants and attract new industry to the lower Mahoning and Beaver Rivers, thus maintaining or increasing property values along the stream. The effect of waste effluent constituents contributing directly or indirectly to taste and odor in municipal supplies will be reduced.

The waterway will do more than serve as a commercial navigation facility. Based on current trends, this connecting link between the Ohio River and the Great Lakes may be expected to be used extensively for recreational boating as well as for commercial navigation, and the maintenance of clean waters along the network will enhance its use. The provision of storage in Summit Reservoir to regulate flow for water quality control will greatly enhance the aesthetic appearance of the Beaver-Mahoning River waterway and make the canal available for recreational use. Recreational users may be expected to come from a wide area.

Considering the current activities of local communities and industries in the Beaver-Mahoning River Basin, the pollution control programs of Ohio and Pennsylvania, the program of the Ohio River Valley Water Sanitation Commission, and the construction grants program under the Federal Water Pollution Control Act, it is reasonable to expect that adequate treatment of municipal wastes or treatment and/or control of industrial wastes can be achieved by water users along the Mahoning River. Assurances should be

obtained from the Ohio and Pennsylvania water pollution control agencies that adequate treatment will be required of municipalities and industries discharging waste effluents to the Mahoning River. Benefits as described above and evaluated below are considered to be widespread in nature.

When possible, the value of providing storage to meet quality control flow schedules is determined by assessing tangible and intangible benefits that are identifiable and result from water quality improvements that will be realized by streamflow regulation. Where no appropriate means can be found for direct evaluation, the cost of achieving equivalent results by the most likely alternative means may be used as an approximation of this value.

Several proposals have been considered in past studies that would provide storage needs from runoff originating within and outside the Mahoning River Basin. The diversion of flood flows from the basin to a reservoir on the Grand River is one means previously reported on.[6/] This is similar to the present canal proposal except that back-pumping would be used to withdraw water from storage when required in the Mahoning River. Another method considered is to store runoff in the Allegheny River Basin and pump over the divide between the basins when water is need for flow regulation in the Mahoning River. Another means is the provision of more impoundments within the Mahoning River Basin, although the number of sites remaining is limited. The Eagle Creek site has been previously investigate and preliminary estimates indicated that storage of 100,000 acre-feet might be possible. Current development in the reservoir area may increase the cost so much as to preclude construction.

While provision of a storage reservoir in the Grand River Basin to store flood flows from the upper Mahoning River as well as a portion of the Grand River Basin appears to offer the greater number of advantes, it has been concluded that the evaluation of costs of storage at a particular site, and the costs of associated facilities, is beyond the scope of the present report. The value of the benefits of storage for quality control needs has therefore been evaluated in terms of the cost of reservoirs within the Mahoning River Basin. The annual draft on storage needed to meet the quality control flow schedule has been determined for each year as the sum of the monthly flow deficits. The annual storage requirements were then arranged in order of magnitude and the draft on storage needed to assure the scheduled flows in 90 percent of the years was selected. The storage needed at selected future times in the absence of the canal project are tabulated below:

Year	Average Scheduled Flow at Youngstown, cfs	Draft on Storage acre-ft/yr
1960	387	50,000
1980	480	107,000
2010	565	151,000
2060	723	253,000

No allowance has been made in draft on storage quantities for consumptive or evaporative losses at the reservoir as these losses should be determined for the specific site selected.

Since the canal project will drastically alter the hydrologic characteristics of the stream network, the navigation system is expected to damage

the stream quality unless canalized flows are increased over those presently existing. The annual draft on storage required to meet the quality control flow needed under canalized conditions in 90 percent of the years is tabulated below for selected future dates:

Year	Average Scheduled Flow at Youngstown, cfs	Draft on Storage acre-ft/yr
1960	584	169,000
1980	663	208,000
2010	756	276,000
2060	966	427,000

The value of benefits resulting from provision for flow regulation for quality control as a part of the canal project, i.e., provision of storage to provide the quality control flows needed under canalized conditions, is considered equal to the cost of a single-purpose reservoir providing storage to meet the uncanalized schedules. The estimated value of the benefits are shown in the following table:

Year	Capital Cost, dollars	Annual Amortized Cost dollars	Annual Operation & Maintenance, dollars	Value of Total Annual Benefit, dollars
1960	9,500,000	300,000	18,000	318,000
1980	30,500,000	965,000	55,000	1,020,000
2010	35,000,000	1,100,000	65,000	1,165,000
2060	42,000,000	1,330,000	75,000	1,405,000

The cost of storage is based on generalized data on the cost of reservoirs in the general vicinity. A more refined estimate of costs should be made by the construction agency in final project evaluation.

If storage to meet quality control needs is not provided in the canal project, the value of the project should be reduced in proportion to the value of the increased storage needed under canalized conditions. Based on the average increase in draft on storage needs over the next 100 years, canalization will result in an increase in the cost of maintaining acceptable water quality estimated to amount to $1,250,000 per year, evaluated in terms of the cost of a single-purpose reservoir.

Provision of increased flow in accordance with the regulated streamflow schedules set forth above will benefit industry by increasing the capacity of the Mahoning River to accept heat loads, which will result in a reduction in streams temperatures. Excessive water temperature is an acute problem in the Mahoning River during low flow periods.

The problem of excessively high stream temperatures has been the subject of considerable study by the group of industries in the Youngstown-Warren area. Their concern has been evidenced by their willingness to participate in building reservoir projects to regulate flow for the purpose of temperature control. Reduced temperature of industrial cooling water supplies will increase plant efficiencies. Based on earlier estimates of the benefits of reduced cooling water temperatures by the principal water-using industries in the Youngstown-Warren area, the value of a 1 degree decrease in the average annual water temperature at Youngstown is estimated at $57,000 per year for the cooling water use anticipated. The provision of the flows needed under canalized conditions will result in lower temperatures, as estimated below, and provide annual benefits as follows:

Year	Average Annual Water Temperature Reduction °F	Value of Annual Benefit dollars
1960	6	342,000
1980	10	570,000
2010	14	800,000
2060	22	1,250,000

Reduction of river water temperatures under present flow conditions to 93°F by off-stream thermal treatment is considered the equivalent of adequate treatment for purposes of this report as required under provisions of the Federal Water Pollution Control Act. Although evaluated separately, temperature control would be provided by the single-purpose reservoir so that these benefits are not additive.

It is of value to note that due to the interdependence of stream temperature and the ability of the river to assimilate organic waste loads, reducing stream temperature by off-stream thermal treatment would allow a general reduction in the quality control flows. Although a stream temperature of 93°F has been accepted as a quality objective at this time, further off-stream cooling is an alternative means of reducing storage needs for quality control. As the availability of developable storage decreases, a lower temperature objective may be considered more reasonable from an economic standpoint where significant organic wastes are also considered. It is estimated that reduction of the temperature of heated water discharges to ambient temperatures would reduce the annual flow requirements under canalized conditions by 193 cfs although some of this would be lost by increased evaporation.

Grand River Basin

Maintenance of acceptable water quality in the lower Grand River would require increased streamflow after about 1990. Maintenance of recommended flows through the natural river outlet will prevent the development of low dissolved oxygen levels and possible nuisance conditions within the Painesville-Fairport area, thereby improving the river from an aesthetic standpoint and for possible reuse by industry. An estimated 7,500 acre-feet of draft on storage will be needed by 2010 to maintain flow necessary to realize the water quality objectives established for this reach of river. By 2060 draft on storage requirements will increase to 20,000 acre-feet.

The provision of this amount of storage in a single-purpose project is considered to be the most likely means the area would elect to pursue to maintain water quality. In the absence of a more economical means of maintaining water quality, the value of the benefits is considered at least equal to the cost of providing the single-purpose storage facility. A 20,000 acre-foot reservoir in this area would cost about $5,000,000. After discounting the capital cost from 1990, the time of first need, and capitalizing the annual operation and maintenance costs over the period of use between 1990 and 2060, the annual value of benefits for including quality control storage in Summit Reservoir to meet quality control objectives in 2010 and 2060 is estimated to be $34,500 and $75,000, respectively, based on a 100-year project life and 3 percent Federal interest rate.

IX. BIBLIOGRAPHY

1. Water Inventory of the Mahoning and Grand River Basins and Adjacent Areas in Ohio, Report No. 16, Ohio Water Plan Inventory. Ohio State Department of Natural Resources, Columbus, Ohio, April 1961. 90 pp.

2. Report of Water Pollution Study of Mahoning River Basin Including Ohio Portion of Shenango River Drainage Basin, 1952-1953-1954. Ohio State Department of Health, Division of Sanitary Engineering, Water Pollution Control Unit, Columbus, Ohio, October 1954. 91 pp.

3. Industrial Water Use in Ohio. Ohio State Department of Natural Resources, Division of Water, Columbus, Ohio, December 1960.

4. Heated Discharges--Their Effect on Streams, Pub. No. 3. Pennsylvania State Department of Health, Division of Sanitary Engineering, Bureau of Environmental Health, Harrisburg, Pennsylvania, January 1962. 105 pp. (A report by the Advisory Committee for the Control of Stream Temperatures to the Pennsylvania Sanitary Water Board.)

5. Woodward, Richard L., and Maurice LeBosquet, Mahoning River Investigation, Effects on Water Quality of Proposed Lake Erie-Ohio River Canal. U. S. Public Health Service, Sanitary Engineering Center, Cincinnati, Ohio, March 1947. 12 pp.

6. Tsivoglou, Ernest C., and Maurice LeBosquet, Mahoning River Investigation, Effects on Water Quality of Proposed Mahoning-Grand River Diversion. U. S. Public Health Service, Sanitary Engineering Center, Cincinnati, Ohio, 1949. 17 pp.

7. Rudnick, Anthony R., Municipal Water Supply in Ohio, 1955 and 1957, Report No. 9, Ohio Water Plan Inventory. Ohio State Department of Natural Resources, Division of Water, Columbis, Ohio, July 1962. 88 pp.

8. Tarzwell, Clarence M., Water Quality Criteria for Aquatic Life, Biological Problems in Water Pollution. U. S. Public Health Service, Sanitary Engineering Center, Cincinnati, Ohio, 1957. 272 pp.

Pertinent Prior Reports

Physical and Economic Aspects of Possible Low-Water Development of the Mahoning River Basin with Particular Reference to the Proposed Berlin Reservoir. U. S. Public Health Service, Cincinnati, Ohio, July 2, 1941. (Memorandum report to the Division Engineer, U. S. Army Engineer Division, Cincinnati, Ohio.)

Mahoning-Beaver Canalization, Beaver River Basin. U. S. Public Health Service, Cincinnati, Ohio, November 1942. 13 pp. (Memorandum report to the District Engineer, U. S. Army Engineer District, Pittsburgh, Pennsylvania.)

Effects on Pollution Conditions of Proposed Canalization of the Mahoning-Beaver River. U. S. Public Health Service, Cincinnati, Ohio, November 16, 1942. (A report to the Division Engineer, U. S. Army Engineer Division, Cincinnati, Ohio.)

Upper Mahoning River Flood Wasteway. U. S. Public Health Service, Cincinnati, Ohio, March 1944. (A report to the District Engineer, U. S. Army Engineer District, Pittsburgh, Pennsylvania.)

Woodward, Richard L., and Maurice LeBosquet, Mahoning River Investigation, Effects on Water Quality of Proposed Lake Erie-Ohio River Canal. U. S. Public Health Service, Sanitary Engineering Center, Cincinnati, Ohio. March 1947. 12 pp. (A report to the District Engineer, U. S. Army Engineer District, Pittsburgh, Pennsylvania.)

Tsivoglou, Ernest C., and Maurice LeBosquet, Mahoning River Investigation, Effects on Water Quality of Proposed Mahoning-Grand River Diversion. U. S. Public Health Service, Sanitary Engineering Center, Cincinnati, Ohio, 1949. 17 pp. (A report to the District Engineer, U. S. Army Engineer District, Pittsburgh, Pennsylvania.)

Shenango River Reservoir, Supplemental Report on Low Flow Regulation Benefits for Pollution Abatement. U. S. Public Health Service, Cincinnati, Ohio, July 1951. (Memorandum report to the District Engineer, U. S. Army Engineer District, Pittsburgh, Pennsylvania.)

Cross, W. P., M. E. Schroeder, and S. E. Morris, Water Resources of the Mahoning River Basin, Ohio with Special References to the Youngstown Area, Geological Survey Circular 177. U. S. Department of the Interior, Geological Survey, Washington, D. C., 1952. 57 pp.

Mahoning River Investigation, Effects on Water Quality of Proposed West Branch Reservoir. U. S. Public Health Service, Cincinnati, Ohio, October 1956. 23 pp. (A report to the District Engineer, U. S. Army Engineer District, Pittsburgh, Pennsylvania.)

Appendix A

Municipal Waste Facilities
Beaver-Mahoning and Grand River Basins
1962

Community	Population 1960	Est. Population Served, 1962	Avg. Daily Flow, mgd	Treatment	Discharge to:	Water Course Mileage	1962 - PE	
							Untreated Waste	Discharged Waste
Ohio								
Alliance	23,362	28,400	2.600	Secondary	Mahoning River	320.7-30.3	21,600	4,680
Andover	1,116	1,115	0.080	"	Branch to Shenango River	322-79.5	1,115	220
Beloit	877	875	X	(By Sebring)				
Campbell	13,406	13,405	1.423	Primary	Mahoning River	320.7-19.3	11,200	6,340
Canfield	3,252	3,250	0.614	Secondary	Meander Cr. to Mahoning R.	320.7-29.3-10.3	4,730	520
Chardon	3,154	3,155	0.483	Secondary	Big Cr. to Grand River	313-13	3,150	395
Columbiana	4,164	4,165	0.513	Secondary	Mill Cr. to Mahoning River	320.7-20.4-15.9	6,450	665
Cortland	1,957	1,955	X	"	Mosquito Cr. to Mahoning R.	320.7-29.4-11.9	970	80
Craig Beach	1,139	1,140	X	(By Mahoning) (Milton, S.D.)				
Garrettsville	1,662	1,660	X	Secondary	Eagle Cr. to Mahoning River	X	1,660	X
Girard	12,997	12,995	X	Secondary	Mahoning River	320.7-23.0	12,995	X
Grand River	477	475	X	Home	Grand River	X	475	475
Hiram	1,011	1,010	0.047	Secondary	Eagle Cr. to Mahoning R.	X	1,010	X
Hubbard	7,137	7,135	1.178	Secondary	Little Yankee Cr. to Yankee Cr. to Shenango R.	X	10,800	1,590
Jefferson	2,116	2,115	0.305	"	Mill Cr. to Grand River	042-8	1,970	215
Lowellville	2,055	2,055	0.241	Primary	Mahoning River	320.7-11.4	2,500	1,130
McDonald	2,787	2,785	0.254	Primary	Mahoning River	320.7-27.9	2,270	1,335
Mahoning Co. Austintown, S.D.	-	1,400	X	(By Youngstown)				
Mahoning Co. Boardman, S.D.	-	12,250	X	" "				
Mahoning Co. Milton, S.D.	-	1,140	0.100	Secondary	Mahoning River	X	920	110
Mahoning Co. Pine Hollow, S.D.	-	180	X	(By Youngstown)				

Appendix A (Cont.)

Municipal Waste Facilities
Beaver-Mahoning and Grand River Basins
1962

Community	Population 1960	Est. Population Served, 1962	Avg. Daily Flow, mgd	Treatment	Discharge to:	Water Course Mileage	BOD - PE	
							Untreated Waste	Discharged Waste
Hickory Twp. Mercer Co.	12,635	4,000	0.400	Secondary	Shenango River	B12-21	X	X
Highfield	2,471	X	X	(To Butler City)				
Jamestown	897	300	X	Primary	Shenango River	B21-53	X	X
Koppel	1,389	X	X	Primary	Beaver River	B11	X	X
Linesville	1,255	850	X	None	Linesville Creek	B21-73-1	X	X
Lyndora	3,232	X	X	(To Butler)				
Mars	1,522	1,520	0.100	Primary	Breakneck Creek	B12-27-8	X	X
Mercer	2,800	3,100	X	Primary	Neshannock Creek	B21-3-2?	X	X
Neshannock Twp. Lawrence Co.	7,421	X	X	(By New Castle)				
New Bedford	600	X	X	None	Mahoning River	B21-12	X	X
New Brighton	8,397	10,000	0.500	Primary	Beaver River	B2	X	X
New Castle	44,790	47,000	4.000	Primary	Mahoning River	B21-3	X	X
Patterson Heights	816	X	X	(By Beaver Falls)				
Patterson Twp.	2,930	X	X	(By Beaver Falls)				
Rochester Twp. Beaver Cr.	3,863	1,200	X	(To Rochester Area) (Joint Sewer Author.)				
Saxonburg Butler Co.	876	900	0.180	Secondary	Thorn Cr.	B12-37-7	X	X
Sharon	25,267	X	X	Secondary	Shenango River	B21-25	X	X
Slippery Rock	2,563	3,500	0.200	Secondary	Slippery Rock Cr.	B12-5-22	X	X
S. New Castle	955	X	X	(To New Castle)				
Taylor Twp. Lawrence Co.	1,402	900	0.080	Primary	Beaver River	B21	X	X
Union Twp.	7,161	X	X	(By New Castle)				
Wampum	1,085	700	0.030	Primary	Beaver River	B14	X	X

Appendix A (Cont.)

Municipal Waste Facilities
Beaver-Mahoning and Grand River Basins
1962

Community	Population 1960	Est. Population Served, 1962	Avg. Daily Flow, mgd	Treatment	Discharge to:	Water Course Mileage	B12 - P5	
							Untreated Waste	Discharged Waste
West Mayfield	2,201	X	X	(By Beaver Falls)				
West Middlesex	1,301	1,300	0.065	Primary	Shenango River	B21-21	X	X
Wheatland	1,813	X	X	(By Farrell)				
White Twp.	1,437	550	X	(By Beaver Falls)				
Zelienople	3,284	4,000	0.350	Secondary	Connoquenessing Creek	B12-25	X	X

X - unknown.
(-) - does not pertain.

Appendix B

Industrial Waste Facilities
Beaver-Mahoning and Grand River Basins
1957

Community	Industry	Industrial Group[a]	Avg Daily Flow, mgd	Treatment[b]	Discharge to:	Water Course Mileage	BOD - PE Discharged Waste
Ohio							
Alliance	Alliance Ware, Inc.	34	X	L	Mahoning R.	B20.7-80.3	X
	Babcock & Wilcox	34	X	11	"	B20.7-79.3	X
	Barns Provision Co.	20	X	CsFs	Beech Cr., Mahoning R.	X	X
	John Liber Co.	20	X	CsFs	Mahoning R.	X	X
	Transue & Williams Steel Co.	34	X	S	"	B20.7-80.3	X
Campbell	Youngstown Sheet & Tube Co.	29	X	11	"	B20.7-15.3	X
	"	33	24.	C	"	"	X
	"	34	X	11	"	"	X
	"	34	19.5	Cm			
Girard	Ohio Leather Co.	31	X	S	Squaw Cr., Mahoning R.	B20.7-25.8-0.2	X
	Unger Bros.	20	X	S	Mahoning	X	X
Hubbard	Youngstown Sheet & Tube Co.	33	1.0	1	Little Yellow Cr., Yankee Cr., Shenango R.	X	X
Lake County, Plainville Twp.	Allied Chemical & Dye Corp.	28	X	SC10	Grand R.	X	X
Lake County, Perry Twp.	Calhio Chemicals, Inc.	28	X	L10	Red Cr., Grand River	X	X
Lowellville	Sharon Steel Corp.	33	1.0	C	Mahoning R.	B20.7-11.6	X
	"	33	10.3	Cm	"	"	X
	"	34	X	11	"	"	X
McDonald	U.S. Steel Corp.	34	X	None	"	B20.7-27.8	X
	"	34	48.8	Cm	"	"	X
Mahoning County	American Fire Clay Co.	39	X	SL	Indian R., Mill Cr., Mahoning R.	X	X
Masury	General American Transportation Co.	34	X	7	Yankee Cr., Mahoning R.	B20.7-23.7-1.1	X
Newton Falls	Standard Steel Spring Co.	34	X	CSL	Mahoning R.	B20.7-55.3	X
Niles	General Electric Co.	39	X	SCm	"	X	X
	"	39		K	"	X	X
	Mahoning Valley Steel Co.	34	X	L	"	B20.7-29.5	X
	Ohio Galvanizing & Mfg. Co.	34	X	None	"	B20.7-28.3	X
	Republic Steel Corp.	33	X	11	"	B20.7-29.5	X
	Sharon Steel Corp.	34	X	None	"	"	X
Portage	Industrial Silica Co.	14	X	L	Eagle Cr., Mahoning R.	X	X

Appendix B (Cont.)

Industrial Waste Facilities
Beaver-Mahoning and Grand River Basins
1957

Community	Industry	Industrial Groups[a]	Avg. Daily Flow, mgd	Treatment[b]	Discharge to:	Water Course Mileage	SIC - PE Discharged Waste
Portage County, Deerfield Twp	Peterson Coal Co.	11	X	L	Williams Cr., Mahoning R.	X	X
Portage County Nelson Twp.	Harbison Walker Refractories Co.	14	X	L	Tinker Cr., Eagle Cr., Mahoning R.	X	X
Ravenna	Ravenna Arsenel (Georges Rd. Pt.)	28	X	CFLA89	West Branch of Mahoning R.	X	X
	Ravenna Arsenel (Sand Cr. Plant)	34	X	CFLA89	Sand Cr.	X	X
Struthers	Youngstown Sheet & Tube Co.	34	16.0	Cn	Mahoning R.	B20.7-13.9	X
Trumbull County, Weatherfield Twp.	Ashland Oil & Refining Co.	29	X	7L	"	X	X
Trumbull County, Howland Twp.	General Motors Corp.	34	X	KDn	Red R., Mahoning R.	X	X
Trumbull County, Kinsman Twp.	Rieck Dairy Farms	20	X	AaC	Pymatuning Cr., Shenango R.	X	X
Warren	Copperweld Steel Co.	33	X	CFBCL	Mahoning R.		X
	General Electric Co.	34	X	8	"	B20.7-34.3	X
	Republic Steel Corp	29	6.5	11	"	X	X
	"	33	X	Cn	"	B20.7-34.4	X
	"	33	X	8L	"	"	X
						"	X
Youngstown	Allied Chemical & Dye Co.	26	X	7	"		X
	Cold Metal Products Co.	34	X	11	"	X	
	Fitzsimmons Steel Co.	34	X	None	"	B20.7-21.0	X
	General Electric Co.	39	X	None	"	"	X
	Koppers Co.	29	X	7-11	Crab Cr., Mahoning R.	X	X
	Lloyd Packing Co.	20	X	CsFs	Meander Cr., Mahoning R.	X	X
	Republic Steel Corp.	29	X	11	Mahoning R.	X	X
	"	33	150.	Cn	"	B20.7-16.3	X
	"	34	X	None	"	"	X
	"	34	40.	Cn	"	"	X
	U.S. Steel Corp	33	15.	C	"	"	X
	"	34	X	None	"	X	X
	"	34	4.3	Cn	"	X	X
	Wilcoff Co.	34	X	None	"	X	X
	Youngstown Sheet & Tube Co.	29	X	11	"	X	X
	"	33	3.4	C	"	B20.7-21.8	X
	"	34	X	8-11	"	"	X
	"	34	5.5	Cn	"	"	X
	Zimmerman Packing Co.	20	X	CsFs	"	X	X

Appendix B (Cont.)

Industrial Waste Facilities
Beaver-Mahoning and Grand River Basins
1927

Community	Industry	Industrial Group[a]	Avg. Daily Flow, mgd	Treatment[b]	Discharge to:	Water Course Mileage	Discharges Waste
Pennsylvania							
Beaver County North Sewickley Twp.	Lisbon Laboratories, Inc.	28	X	None	Connoquenessing Cr.	X	X
	Townsend Co.	34	0.1352	None	"	X	X
Beaver County West Mayfield Twp	Babcock & Wilcox Tube Co.	34	1.6	T	Wallace Run to Beaver River	X	X
Beaver Falls	Armstrong Cork Co.	39	0.016	None	Beaver River	X	X
	Ingram Richardson Mfg. Co.	34	0.002	None	Walnut Run to Beaver River	X	X
Bessemer	Robinson Industrial Waste Co.	34	0.03	L	Hickory Cr.	X	X
Butler	Armco Steel Corp.	34	2.016	KsCn	Connoquenessing Cr.	X	X
	Franklin Glass Corp.	39	X	L	"	X	X
Butler County	B&O Railroad	X	X	None	-	X	X
	Alson Dairies	20	0.0048	X	"	X	X
	Mine Safety Appliance Co.	39	0.05	None	Breakneck Cr.	X	X
	Union Dairymens Co-op Assn.	20	0.001	Is	Unnamed tributary to Muddy Isle Cr.	X	X
	Michigan Limestone & Chemical Co.	14	0.60	None	Slippery Rock Cr.	X	X
	Comaco, Inc.	34	0.0002	S	S. Branch of Glade Run	X	X
	Franklin Glass Corp.	39	0.017	L	Connoquenessing Cr.	X	X
Ellwood City	National Tube Co., Inc.	34	0.015	X	"	X	X
Fallston	Townsend Co.	34	0.066	None	Beaver R.	X	X
Grove City	Cooper-Bessemer Corp.	34	0.072	TL	Wolf Cr.	X	X
Lawrence County	Superior Sand & Supply Co.	14	0.312	L	Hottenbaugh Run	X	X
	American Cyanamid & Chemical Co.	28	0.15	SL	Mahoning River	X	X
	Universal-Rundle Corp.	39	0.1606	CKcLsE	Shenango R.	X	X
	West Penn Mirror, Inc.	39	0.05	CCs	Beaver R.	X	X
Mercer	Mercer-Walker Mfg. Co.	34	X	None	Otter Cr.	X	X
Mercer County Hickory Twp.	Deneens Dairy	20	0.006	L	Shenango R.	X	X
	Sharon Rendering Co.	20	0.004	None	Unnamed tributary to Shenango R.	X	X
	W. B. Taylor Sand & Gravel Co.	14	0.24	None	Shenango R.	X	X

Appendix B (Cont.)

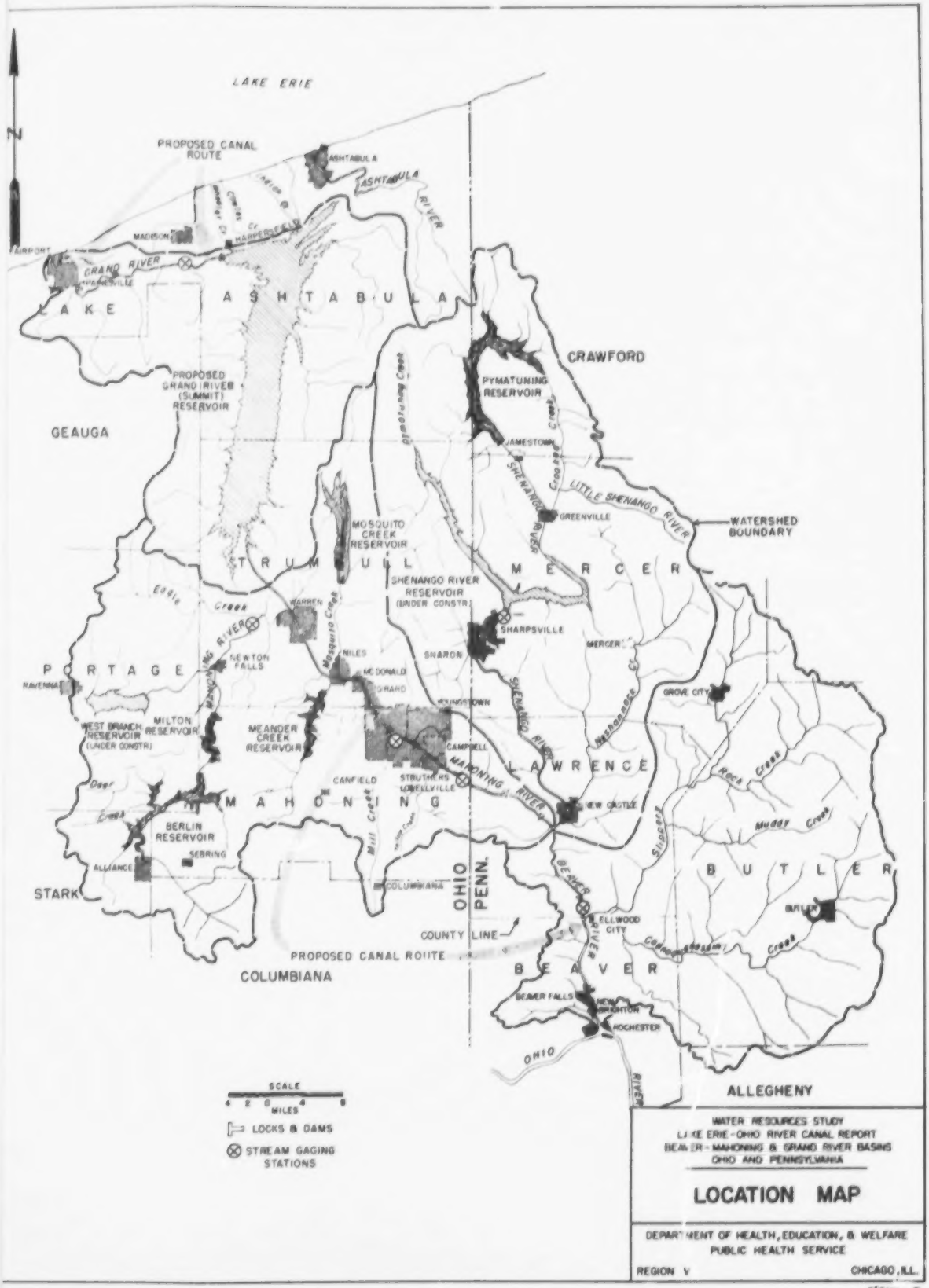
Industrial Waste Facilities
Beaver-Mahoning and Grand River Basins
1957

Community	Industry	Industrial Group[a]	Avg. Daily Flow, mgd	Treatment[b]	Discharge to:	Water Course Mileage	B.D - DE Discharged Waste
Mercer County							
Jefferson Twp.	Seisel Sand & Gravel Co.	14	X	None	Tributary to Shenango R.	X	X
Mercer County							
S. Pymatuning Twp.	Transfer Sand & Gravel Co.	14	0.24	L	Pymatuning Cr. to Shenango R.	X	X
Mercer County							
Shenango Twp.	Seger Sand & Gravel Co.	14	0.05	None	Shenango R.	X	X
New Castle	Blair Strip Steel Co.	34	0.017	KcL	Big Run	X	X
	E. I. de Nemours de Pont & Co.	28	0.019	Kc	Shenango R.	X	X
	Irwin Separation Works	39	X	None	Neshannock Cr.	X	X
	Mooney Bros. Supply Corp.	14	0.12	L	Shenango R.	X	X
	National Radiator Co.	34	0.016	Ip	Ground	X	X
	Superior Sand & Supply Co.	14	X	C	Hottenbaugh Run	X	X
	Timkin-Detroit Axle Co.	34	8.		Shenango R.	X	X
	United Engineering & Foundry Co.	33	X	CL	"	X	X
New Wilmington	New Wilmington Cheese Co.	20	0.007	FtC	Little Neshannock Cr.	X	X
Sharon	Mercer Tube & Mfg. Co.	34	0.016	KL	Shenango R.	X	X
	National Malleable Iron	33	X	None	"	X	X
	Sharon Steel Corp.	34	1.017	SF	"	X	X
	Sharon Tube Co.	34	0.218	Scale Pit	"	X	X
	Westinghouse Electric Mfg. Co.	34	0.105	SKc	"	X	X
Sharpsville	Shenango Furnace Co.	34	X	C	"	X	X

[a] 11 - antracite, bituminous coal, and legnite mining.
14 - mining and quarrying of nonmetallic minerals, except fuels.
20 - food and kindred products.
28 - chemicals and allied products.
29 - products of petroleum and coal.
31 - leather and leather products.
33 - primary metal industries.
34 - fabricated metal products.
39 - miscellaneous industries.

[b] A - aeration.
Aa - activated sludge, mechanical aeration.
C - settling tanks.
Cm - mechanically equipped.
Cp - plain, hopper bottom or intermittently drained for cleaning.
Cs - septic tank
E - chlorination
F - filters.
Fs - intermittent sand.
Ft - trickling (no further details).
Ip - percolation beds.
Is - subsurface application.
K - chemical treatment (flocculation). Chemical treatment-type units or equipment not necessarily complete or operated as chemical treatment.
Kc - chemicals used.
L - lagoons.
Ls - sludge lagoons (not for treatment of sewage).
S - screens.
7 - flotation.
8 - neutralization.
9 - oxidation - chemical.
10 - regulated discharge.
11 - waste prevention measures (good).

X - unknown.



WATER RESOURCES STUDY
LAKE ERIE - OHIO RIVER CANAL REPORT
BEAVER - MAHONING & GRAND RIVER BASINS
OHIO AND PENNSYLVANIA

LOCATION MAP

DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION V CHICAGO, ILL.

FIGURE I